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THE UNIVERSITY OF ALBERTA

CRITERION-REFERENCED ASSESSMENT OF MOTOR DEVELOPMENT: A VALIDATION STUDY

by

© HELEN MARINA MADILL

A THESIS

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DEDICATION

The completion of this graduate degree was made possible by the Goldwin-Howland Scholarship awarded to the author in June 1976 by the Canadian Association of Occupational Therapists.

Dr. Goldwin-Howland served as the first president of the national association between 1924 and 1948. His contribution to the profession of occupational therapy was acknowledged by the creation of a scholarship bearing his name for continuing education purposes.

ABSTRACT

A validation study of the first seven items within a criterion-referenced assessment of motor skill development was undertaken using a heterogeneous group of subjects in order to determine if the sequence of objectives possessed ordinality. Hearing-impaired, Down's syndrome, and unimpaired subjects made up the sample of twenty-six subjects. The proposed sequence of objectives was found to be scalable. It was concluded overall that this sequence of motor skills was ordinal and could be classified as ordinal data when used in further research. Anthropometric measures were found to be related to motor development in the component areas of postural maintenance and postural assumption, but not to locomotion within this sample. Recommendations were made for the modification of the instrument when used for both programming and research purposes.

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CHAPTER I

STATEMENT OF THE PROBLEM

Historically, investigators in the field of motor development did not go beyond measurement; they designed assessment tools in order to establish "norms" by which an examiner could determine the status of a particular child in relation to others of the same age and sex. This type of assessment is referred to as norm-referenced testing. Normative assessment prodedures "compare an individual's achievement on a test to the relative achievement obtained by a group of performers who have previously taken the same test" (Baine, as in Das and Baine, 1977).

Motor development was first assessed in the physical medicine milieu, in which diagnosis was central to the treatment of motor delay. This "medical model" suggested that "there must be some underlying disease to which the symptoms can be attributed" (Craighead, Kazdin and Mahoney, 1976, p. 95), and further assumed that once having established and treated the cause of the motor delay, the problem was alleviated. In such circumstances, while the progression of disease may have been halted by treatment, the emphasis was on the total degree of motor delay in comparison to the motorically normal, rather than analysis of specific areas of motor difficulty. The expected performance levels within different diagnostic categories such as cerebral palsy and mental retardation, were gradually determined using norm-referenced assessment procedures. Such workers as Milani-Comparetti (1967), Sheridan (1968), Bayley (1935, 1969), Gesell and Amatruda (as edited by Knobloch and Pasamanick, 1974) and Illingworth (1975) contributed longitudinal data and developed assessment instruments for this purpose.

One of the difficulties with norm-referenced assessments is that they are generally not suitable as diagnostic instruments. Items are randomly selected and are representative of the general content area. They are retained if it can be demonstrated that they discriminate between different levels of performance. Therefore the reliability, "the accuracy with which the sample of items represents the universe from which they were drawn" (Tinkelman, as in Thorndike, 1971, p. 71), and the content validity or "how well the content of the test sample the class of situations or subject matter about which conclusions are drawn" (Cronbach, as in Thorndike, 1971, p. 444), are frequently too low or inadequate for diagnostic purposes. For diagnostic purposes, the examiner relies largely on inferences made on the basis of the subject's level of performance and the sensory modality that the test purports to measure.

Much of the original work in assessment of motor development was performed by Gesell and his colleagues at Yale Clinic of Child Development between the early thirties and the late fifties. The work of Illingworth (1975, Bayley (1935, 1969), and Sheridan (1968) followed. Each author contributed studies based on Gesell's original principles of child development. Coming from a medical and psychological background, Gesell adhered to a theory of child development based on the maturation of the central nervous system. Gesell's approach was based on the following premises:

1. Only the rate of development differs between children, not the sequence.
2. Generalized mass activity is gradually replaced by specific intentional responses.

3. Primitive reflexes "such as the grasp reflex and walking reflex, have to be lost before the corresponding voluntary movement is acquired" (Illingworth, 1975, p. 131).

4. Development takes place in a proximodistal direction, accounting for the control of large joints (shoulder) and gross movement before small joints (carpal and metacarpal) and fine movement.

This approach led to such statements as "no amount of practice can cause a child to walk until his nervous system is ready for it" (Illingworth, 1975, p. 131). Development was seen as a continuous, sequential process taking place in a cephalocaudal direction, i.e., "the first step towards walking is the development of head control" (Illingworth, 1975, p. 131).

This previous research has provided detailed longitudinal observational accounts of child development in the following areas: "posture and large movements. . .vision and fine movements. . .hearing and speech. . .social behavior and play" (Sheridan, 1968, pp. 4 - 5), but did not provide sufficient detail to answer the question: What is the best way to structure remedial programs for those children who deviate from the pattern of development average children have been observed to follow? The approach of norm-referenced testing, while invaluable as an instrument through which exceptionality can be detected and the extent of deviation from the norm known, does not provide an indication of an individual child's strengths and weaknesses. Derived scores from these assessments reported as standard scores, percentile ranks, or "developmental quotients" (Gesell and Amatruda, 1947), unfortunately tell the examiner little about the functional abilities of the individual child.

A potential solution to this dilemma may be the use of a criterion-referenced assessment procedure. Criterion-referenced assess-

ment compares "an individual's achievement to a sequence of instructional objectives" (Baine, as in Das and Baine, 1977) in order to indicate which particular prerequisite skills within each sub-area have been attained. The construction of the criterion-referenced test differs from the norm-referenced test. As described by Baine (as in Das and Baine, 1977) a general content area is divided into sub-content areas and a final instructional objective written for the highest level of achievement within each sub-area. An analysis of the final objectives determines which of the sub-skills are necessary to achieve each objective. The sub-skills are described in terms of sub- or enabling objectives which are sequenced in order of complexity. Each enabling objective is defined according to the performance standards or criteria that the subject must achieve to demonstrate that he has mastered or learned that particular sub-skill. Criterion-referenced testing therefore compares the subject's performance to the criteria specified for each sub-skill along the sequence of objectives and in their order of difficulty. Items or sub-skills are maintained within the test if their mastery is essential to the performance of the final or terminal objective.

Such areas as motor development, language and cognitive skills, and self-help skills may be assessed using this approach. Results provide information about the child's ability to master the sequence of enabling objectives within motor areas such as crawling and walking, apprehension of small objects and placing them in a receptacle, following an object with the eyes, turning to a source of noise. The level attained may indicate that the child can perform the final and most complex objective or the highest sub-objective within the sequence that he can perform. In the latter case the appropriate level for

remedial instruction is automatically established.

A specific example follows: sitting ability has been rated on a normative assessment and results indicate that the child is able to sit without support. Within the program situation it is found that the child can indeed sit without support, but must always be placed in the sitting position by an adult. In order for this skill to be functional for the individual, independent movement into and out of the sitting position, and sitting balance on a variety of surfaces are required. A criterion-referenced assessment of sitting ability would include within the sub-objectives, objectives which deal specifically with assumption of the sitting position and maintenance of the sitting posture on a number of surfaces so that mastery of the final objective, the most complex level, would demonstrate independent movement into and out of the sitting position.

The use of criterion-referenced assessments in addition to norm-referenced instruments is suggested as a method of assessing "the nature of competent performance" (Glaser, 1976, p. 21). Results of the criterion-referenced instruments provide information about performance attainments which can be directly related to available remedial and educational options. Interpreted in terms of performance criteria, these instruments keep both learner and teacher informed of the progress being made relative to developing mastery. The criterion-referenced assessment procedure is therefore the first step in the teaching process for the child, because it provides information to the instructor about the starting point of the instructional process.

Few criterion-referenced assessments in the area of motor dev-

elopment appear to exist at the present time. Of those that could be found, none have been validated. Fredericks, Riggs, Turey, Grove, Moore, McDonald, Jordan, Hanson, Baldwin, and Wadlow (1976) have outlined a detailed instructional curriculum (sequence of objectives) and programs which use criterion-referenced assessment to determine mastery level in motor development and other areas for moderately and severely handicapped children. Martin, Murrell, Nicholson, and Tallman (1975) have applied a similar approach to assessment and programming for severely mentally retarded persons. Motor development is assessed in terms of a series of criteria or objectives and the child's level of mastery of these objectives is determined. Kysela, Hillyard, Daly, Doxsey-Whitfield, McDonald, McDonald and Taylor (1976) have developed a criterion-referenced assessment guide to the analysis of motor development, as well as language, cognition and self-help skills. This assessment instrument presents a sequence of objectives in the motor area ranging from simple to complex, for example, sitting supported on the floor when placed in that position, to assuming an unsupported sitting position on a chair or stool independently. The results of this criterion-referenced assessment provide data from which the examiner can estimate a starting point for both parent-implemented and teacher-implemented instructional programming. However, the order of these objectives has yet to be validated as a legitimate scale.

Of particular importance at this point is the use of assessment devices in developing programs for the preschool age child with moderate to severe impairment in such areas as mental retardation, hearing and visual impairment, physical handicap, or combinations of these conditions. Early assessment and training is now becoming the rule

rather than the exception in well-equipped urban areas, and early intervention programs are receiving a great deal of attention in the literature. There is, therefore, a need for clear-cut assessment devices which provide the type of information that relates directly to program development, both in the initial assessment and in the monitoring of progress throughout such a program.

The criterion-referenced assessment appears to offer a method by which detailed and specific information regarding an individual's competencies and difficulties in motor development may be determined. The motor development section of the criterion-referenced assessment device compiled by Kysela et al. (1976) will be validated with a heterogenous group of children in order to determine the ordinality of the proposed sequence of objectives. Included in the sample will be children with Down's syndrome and children with some types of hearing impairment, both of which disabilities have been shown in the literature to delay, in varying degrees, the development of motor skills (Illingworth, 1975; Griffiths, 1976; Boyd, 1967; Myklebust, 1960).

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

This thesis is concerned with testing the ordinality of a criterion-referenced assessment of motor development with a heterogeneous sample. Normal motor development will therefore be briefly discussed as it pertains to the age range in question, two to six years. Both normative and criterion-referenced assessment procedures will be discussed and their application to the assessment of motor skills outlined. A review of the literature pertaining to the motor development of both disability groups represented in the heterogeneous sample will follow and the findings from this work compared to the acquisition of motor skills observed during the course of normal motor development.

Normal Motor Development, Birth to Six Years

During the first two years of life, motor development is rapid. The infant moves quickly from being totally governed by primitive reflex patterns to independent voluntary movement of both upper and lower limbs in bilateral and ipsilateral patterns, the movement of one limb no longer affecting or causing movement of another.

Shirley (1931) outlined the sequence of motor abilities followed by all children, as an invariable fundamental sequence having five divisions:

1. Passive postural control.
2. Postural control of the trunk and undirected activity.
3. Active efforts at locomotion.

4. Locomotion by creeping.

5. Postural control and co-ordination for locomotion by walking (p. 520).

Bayley (1935) failed to confirm an "invariable sequence in specific performances" (p. 15) but supported Gesell's (1928, 1940) observations that the developmental sequence is not dependent on a "regular order of appearance of specific abilities, but rather on rapid increments in the entire level of ability" (Bayley, 1935, p. 15). She showed that the "variability in age attainment of first success on any one item [of the California Infant Scale of Motor Development] is small" (p. 15). Greater variability on motor performance is seen as the child increases in age, while variation in acquiring specific abilities may be related to level of task difficulty. The order in which more advanced motor skills develop may also depend on experience, i.e., opportunity to practice, interest, chance, and amount of activity engaged in by the child.

The age at which the various milestones of motor development are acquired obviously occurs within a particular range. Figures reported by Illingworth (1975) and Gesell and Amatruda (as edited by Knobloch and Pasamanick, 1974) are average for unimpaired children and shown in Table I. Within the medical model variations of three to six months are considered to be within normal limits when clinical assessments of the attainment of milestones are reported. Illingworth (1975) stated that motor skills (as outlined in Table I) are generally acquired "slightly earlier or later than the dates given" (p. 132), but no specific range is included.

Bayley (1935) found that being over or under weight for age may be likely to affect a subject's ability to perform gross motor tasks. Although these effects were not sufficient in themselves to prevent the

TABLE I

MILESTONE ATTAINMENTS IN UNIMPAIRED CHILDREN*

Chronological Level of Development	Position	Attainment
4 weeks	Prone	Head sags, momentarily held up.
16 weeks	Prone	Head steady, held beyond plane of rest of body. Chest off couch.
20 weeks	Prone	Weight taken on forearms.
24 weeks	Prone	Weight taken on extended arms.
28 weeks	Sitting	Sits, leaning forward on hands. Takes weight on feet.
40 weeks	Prone	Crawls on abdomen, creeps. Sits alone. Can move from prone to sit and move into prone position. Pulls to stand.
44 weeks	Four-point kneeling	Crawls on hands and knees.
52 weeks	Bipedal	Walks with help.
13 months	Bipedal	Walks without help.
18 months	Bipedal	Walks without falling. Seats self.

*adapted from Illingworth (1975, pp. 132 - 135); Gesell and Amatruda (as edited by Knobloch and Pasamanick, 1974, p. 11).

attainment of motor milestones, they were found to contribute to the length of time taken to acquire independent walking skills.

Sinclair's (1971) study of the movement development of the average two to six year old provides a good description of the attainments at each age. Two year olds move easily from place to place, aiding their balance with a wide-based gait and arms "carried up and forward" (p. 11). Their chief tasks are to push, pull, drag, and carry objects in play, "providing plenty of practice in postural changes and all types of movement" (p. 11). The three year old has refined his movement pattern and is able "to mobilize. . .body parts for more effective use" (p. 12). A four year old has increased in size, strength and "motor effectiveness" (p. 13), and is more adept in co-ordinated locomotor tasks involving balance skills. By five and six years of age, increased size, strength, and experience provide greater confidence. Sitting and walking skills are semi-automatic by this age, and advanced locomotor skills such as skipping, hopping, running, and jumping are practiced in the course of everyday play. At age six, sex differences begin to show in performance, with boys being more adept than girls in some advanced motor skills.

During the course of normal motor development, the attainment of independent locomotion is acquired through maturation and practice. Sufficient practice is gained during play, and adults rarely attempt to teach such skills as sitting, crawling and walking to the child who is progressing at the normal rate of development. This is not, however, the case in the management of the exceptional child, where two questions arise: How deviant is the child's motor performance in comparison to children of the same age and sex? What level of motor function has

been developed in terms of the child's mastery of specific tasks within the motor area?

Norm-Referenced Assessment

The purpose of a norm-referenced assessment is to make comparison between individuals -- it will therefore answer such questions as how deviant is the performance of an individual in comparison to his peers. An example of such an assessment is the I.Q. test. Norm-referenced tests are designed to facilitate gross decisions relating to general group or program placement, particularly when a limited enrollment is involved. When used for this purpose, cutoff points may be established, especially in the area of intellectual assessment, individuals scoring at or below a certain point being placed in special programs. Norm-referenced procedures yield scores which, when compared with those attained by a group of the same age and sex, will provide information regarding an individual's standing within that group. Results of this type of assessment will estimate how deviant in general the child's performance is in comparison to that of the normative group or population.

Variability amongst the scores is essential, requiring that items discriminate between individuals. Items which are passed or failed by all subjects are therefore eliminated. Content of these assessments may or may not match instructional program goals even though the results of the normative assessment will inevitably be used to determine placement or programming for an individual. Scores obtained on a normative assessment mask what the individual can do -- they only provide an indication of his relative standing (Boehm, 1973). Meaning can only be gained from this type of score when it is converted to a derived score

such as age and grade norms, percentiles, or standard scores, and compared to the performance of other children. The results of normative assessment in the motor area do not provide sufficient information to commence a remedial program. Although items may be sequenced from simple to complex, there is frequently an insufficient number of simple items to estimate the functional level of the exceptional child who deviates markedly in motor skill development from his unimpaired peers. The comparison to the normative group which is unimpaired motorically serves little purpose when attempting to assess the functional level of the motorically handicapped child.

Within the medical model it is the normative assessment which is employed clinically in the assessment of motor skills. Results may be reported in terms of a developmental quotient on the Gesell Scales (1947) or with the Bayley Scales of Infant Development (1969) where a raw score obtained on the Motor Scale is converted to a Psychomotor Development Index. The items on the Bayley Scales are scored on a pass/fail basis. The mean age at which the normative group acquired each of the items is provided as well as an age range describing the minimum and maximum age at which the normative group acquired each item. Analysis of performance on specific items only enables the examiner to make a comparison between the age at which it was acquired by the normative group and the chronological age of the child being assessed. The result with this type of instrument is an estimate of the delay or acceleration in motor performance present at that time for a given child as well as subjective clinical data observed by the examiner during the assessment. It is conceivable that guidance by such statements as "the child is 2.6 years behind his age group in the attainment of motor skills" could result in

selection of ineffective programming for the exceptional child. Placement with children of 2.6 years his junior will likely provide him with poor behavioral models. Many of the skills which they have not yet attained he may have mastered, so that a large proportion of his time will be spent repeating skills he had previously developed. The amount of motor delay in terms of months or years is largely of academic or clinical interest, and of little assistance to the construction of an intervention program.

Criterion-Referenced Assessment

Criterion-referenced assessment compares an individual's performance to criteria specified for each sub-objective along a sequence of increasing complexity, the final objective outlining the highest level of achievement within the sequence.

In the construction of a criterion-referenced assessment, items are included if they are necessary to the mastery of a final or terminal objective or goal. Should an individual be unable to demonstrate proficiency at the terminal objective level, the degree of proficiency attained on a sequence of enabling objectives may indicate the level at which instruction should begin. This is the case in the criterion-referenced assessments developed by Kysela et al. (1976) and Martin et al. (1975).

Criterion-referenced testing requires a clearly defined domain of learning tasks: in this instance, the domain of learning tasks is the motor area. From this domain, a goal statement is outlined and a set of instructional or behavioral objectives is defined in performance terms. Definition in performance terms requires that the conditions are

outlined, i.e., the major essential objects or events which are to be present or absent in the test situation. The most difficult conditions commonly found are selected. The observable performance is defined, that is, the observable, measurable behavior. The simplest performance that fulfills the demand is chosen. The performance standard (the minimum standard for the performance) is outlined: such areas as the time allotted for the task, the number of successful trials to be completed, and the acceptable margin for error are included. In some instances a product is involved, or enduring result. Here the most easily produced item under the most difficult commonly found conditions is chosen (Baine, 1977). The conditions, observable performance and performance standards are specified as in the following example from the Criterion-Referenced Assessment Guide -- Motor Development (see Appendix A).

> "Eye movements on back: In a supine position the child will follow with his eyes a moving object or light which is held at a distance of 15 - 20 cm. from his face and travels in a 180° arc from left to right."

Criterion-referenced assessment is designed to describe a child's performance in terms which will be meaningful without reference to the performance of others. For this reason, criterion-referenced assessment requires a scoring and reporting system that adequately describes subject performance on clearly defined tasks (Gronlund, 1973). This element is particularly important if results are to be of use in remedial program construction.

An examiner may assess a child's behavior "according to the amount of prompting (or) guidance necessary to produce that behavior" (Martin et al., 1975, p. v). Results of such an assessment indicate what a child can do, and at what level of guidance, thus providing a

basis for developing remedial programs at the appropriate level. The assessment procedure provides information that is directly relevant to instructional procedures.

The criterion-referenced assessment format developed by Kysela et al. (1976) differs from other criterion-referenced tests by the use of a "cumulative and sequential introduction of prompts and guidance to assess the child's skills when the child is not responsive at the spontaneous level" (p. 6). A series of verbal and physical prompts are introduced to determine the degree of intervention required in order to obtain a response from the child. On the initial assessment using this instrument each terminal objective is assessed. A spontaneous, correct response at this level indicates that the child has mastered that particular skill. Should the child's performance indicate that he has not mastered the terminal objective, the sequence of enabling objectives for that terminal behavior is assessed. Enabling objectives are sub-skills arranged hierarchically in order of difficulty and it is proposed that each is a prerequisite to the mastery of the terminal objective. The inclusion of each set of sub-skills was derived from a task analysis of the terminal objective, taking into consideration the target population's entry level.

In the development of a criterion-referenced test the instructional sequence is divided into modules. In the model developed by Kysela et al. (1976) for the motor development area, three modules or components were utilized: (1) postural maintenance, referring to the subject's maintenance of a position following correct placment for a specified length of time; (2) postural assumption, the subject's ability to

assume the required position within a specific time period; (3) locomotion or movement, the subject's ability to move whilst maintaining the required position, or ambulate maintaining the required posture. Terminal objectives would normally be included in a "survey test", whilst the inclusion of sub-objectives or enabling objectives constitutes a "diagnostic test" (Baine, 1976). The criterion-referenced assessment of motor development devised by Kysela et al. (1976) is a diagnostic test within a "test-teach model" (p. 5), where the assessment and curriculum development processes are directly related.

Handicapping Conditions

As the criterion-referenced assessment of motor development in actual practice situations will be used with a variety of exceptional groups, a heterogeneous sample has been chosen for this validation study. Children who were known to have disabilities which have been shown in the literature to be detrimental to the acquisition of motor skills were included. In this instance, Down's syndrome and hearing impairment have been selected. A review of the literature pertaining to the motor development in each of these disability groups follows.

Motor development and Down's syndrome: Development of motor abilities in the Down's syndrome child is very slow, especially during the first year, in comparison to that of normal children. Capute and Biehl (1973) describe the motor performance of young mentally retarded children as both "qualitatively and quantitatively" similar to the attainments of a much younger normal child (p. 20). This finding is supported by Griffiths (1976), Illingworth (1975), and Cowie (1970), who note the presence of all primitive reflexes long after they are expected

to disappear.

Some work has been done in an effort to investigate the cause of the Down's syndrome child's marked delay in motor development. An interesting hypothesis regarding the cause of developmental retardation has been advanced by Frith and Frith (1974) from a learning and memory viewpoint. These authors suggest that a deficit in one specific process accounts for the retarded level of motor performance seen in manipulation, co-ordination, and speed dexterity in use of upper limbs: "It is hypothesized that Down's syndrome is associated with specific difficulties in using long term motor programs and that mongol children may therefore be dependent on simple feedback processes to perform motor tasks" (p. 400).

Neurological factors are frequently cited as contributors, and in many instances as primary etiological factors. Cowie (1970) suggests that the hypotonia commonly seen in these children is associated with a maturational delay in the cerebellum, while the persistence of primitive reflexes may be associated with the slow maturation of cortical pathways. Hypotonia is noted by many authors (Illingworth, 1975; Benda, 1960; Hall, 1970; Donoghue, Kirman, Bullmore, Laban and Abbas, 1970; Melyn and White, 1973; Connolly and Russell, 1976; O'Connor and Hermelin, 1963) as a contributor to the delay in motor development as well as the slower speed of movement and clumsiness exhibited by these children.

Crome (1965) investigated the weight of brain stem and cerebellum and found it to be reduced in Down's syndrome cases. In other types of mental retardation, the cerebral hemispheres were found to be mainly involved, and the brain stem and cerebellum not significantly affected. Donoghue et al. (1970) hypothesize that the distribution of

"histological" lesions in lower centres of the brain, "brain stem, cerebellum, midbrain and basal ganglia as well as those areas of the cortex primarily concerned with the process of learning to walk" (p. 789) contribute to the degree of motor impairment. Maturation and development of these centres, presumably delayed by the lesions, is seen as the determinant of the age at which the child will walk, if at all.

Hall (1970) reports that hypotonia disappears as the child reaches six years of age, but also notes that hyperflexibility continues. He does not define the use of either term, but it would appear to be almost impossible to demonstrate hyperflexibility without some degree of hypotonia in this instance. Hall also described a dysplasia of the pelvis which increases between the first and sixth years, presumably influenced by the child's attempts at locomotion.

Biochemical causes outlined by Griffiths (1976) suggest that serotonin levels in the blood of Down's syndrome children are low. While the phenylalanine levels can be lowered by medication, as in Griffiths (1976) and Coleman (1973), Marsh and Cabaret (1975) also report success with dietary control, citing the case of a 17 month old female who showed significant improvements in both physical and mental measurements (Bayley Scale) after receiving a low phenylalanine diet for eight months. The authors report that data from five months of dietary control showed a sustained "accelerated growth rate" in all areas except "psychomotor" (p. 365).

Discovery of causative factors has done little to stimulate the growth of remedial programs designed to correct such deficits as hypotonia. Any programs which have been reported are still based upon the medical model and are being carried out in medical settings (Capute and

Biehl, 1973, Hughes, 1971; Connolly and Russell, 1976; Kugel, 1970). Results of well-controlled studies using any of these techniques could not be found in the literature.

Age of milestone achievements such as sitting, crawling, standing and walking, vary greatly in Down's syndrome children. Table II presents the results of published and unpublished studies pertaining to milestone attainment of Down's syndrome children. The number of subjects in these samples ranges from 20 to 612. When considering findings for groups where N = 50 or more, the age ranges reported for independent sitting vary from 12.5 months to 72 months (7 months is reported for normal motor development, as outlined in Table I). A wide range is again reported for standing, 8 to 84 months (10 months is reported for normal motor development, as outlined in Table I). Where performance of male and female subjects has been reported separately, males generally appear to attain milestones slightly later than females. A similar situation occurs when walking is reported. Attainment of independent walking has received the most attention by the authors represented in Table II. Age of attainment varies greatly from 7 to 74 months (the average age at independent walking reported for normal motor development is 13 months, as in Table I). Illingworth (1975), Fishler, Share and Koch (1964), and Melyn and White (1973) observe that the variation in the individual's level of motor skill increases with age.

Several studies support the importance of early intervention in the development of young Down's syndrome children. Connolly and Russell (1976) found that children referred to their program prior to the age of six months did better than those commencing after six months of age (however, no statistical analysis was completed on the data).

TABLE II

ATTAINMENT OF "MILESTONES" BY DOWN'S SYNDROME CHILDREN
(SITTING, CRAWLING, STANDING, WALKING)

Author	Date	Total No. of Subjects	Male Female Mixed	Age in months at			
				Sitting	Crawling	Standing	Walking
Connolly & Russell	1976	40	Mi	8.0*	8.6*	16.8*	18.4*
Illingworth	1975	600	M	12.5*			26.1*
			F	11.1*			22.7
Melyn & White	1973	612	M	(257) 5-72		(168) 8-84	(242) 7-74
			F	(211) 5-36		(116) 7-72	(188) 8-72
			Mi		**(46) 4-24		
Hall	1970	22	Mi				18-48
Carr	1970	47	Mi				(38) 24-36
Donoghue et al.	1970	70	Mi				(56) 50*
Erbs & Smith (unpublished 1962 data as reported by Donoghue, 1970)							16-48
Kučera	1969	132	Mi				1954 Group 29.93* 1955-60 22.31* 1961-66 22.76*
Penrose & Smith	1966	not stated	Mi	6-30			16-47
Fishler et al.	1964	not stated	Mi	(65) 10-15	(42) 8-34	(36) 12-44	(50) 15-50
Stedman & Eichorn	1964	20	Mi				27.5*
Levinson	1955	50	Mi				12-54

*mean age only reported by author.

**all bracketed numbers indicate actual number in sample.

Centerwall and Centerwall (1960, as in Melyn and White, 1973) found that children who had the advantage of early home training were "superior in nutrition, and growth and motor and mental development" (p. 542). Fields and Gibson (1971) state, tentatively, that "early growth in the mongol is environmentally susceptible" (p. 167). It is environmental rather than physiological predictors of later intellectual performance that bear investigating, although developmental milestones or "markers" can provide information in relation to maturity levels. Fields and Gibson also stress the importance of early intervention programs.

The locomotor capacity of Down's syndrome children is reported to decrease over time (Fishler et al., 1964; Dicks-Mireaux, 1972). Menolascino (1974), in a study of adult Down's syndrome cases (N = 72), found that although 75% of the group could ambulate freely, opportunity for them to use this skill was limited to the daily routine of the institutional setting: "all were generally confined to the widely used institutional concept of 'lowest common denominator' with only a limited number of options available to them" (p. 15). Francis (1970), in a study of institutionalized Down's syndrome persons between the ages of five months and 57 years, observed an increase in incidence of locomotion up to the age of 13 years, followed by a decrease in responsive behavior, characterized by self-oriented behavior and diffuse movements, which may be attributable to the lack of stimulation in the institutional environment. She further noted that "when an increased level of social contact was provided for the institution-reared mongoloid, performance of more advanced, more organized behaviors was encouraged, and fewer diffuse movements and self-oriented behaviors occurred. . .behaving like the home-reared mongoloid" (p. 100). Stedman and Eichorn (1964) support a

lack of experience rather than a lack of basic skills as explanation for motor deficits. It is likely that similar institutional routines hampered the continued use of locomotor skills as reported by Fishler and Dicks-Mireaux so that lack of practice and opportunity to use these skills, rather than physical abnormality, resulted in a decrease in ability.

Another factor that hampers the development of the Down's syndrome child is the expectation level of both professionals and non-professionals, i.e., the notion of "predetermined limited biological maturation which prohibits any advance in the rate of development" (Bidder, Bryant and Gray, 1975, p. 385). This statement was made in relation to locomotor skills. In the programs of these authors, no attention was devoted to locomotor skills as "it was considered not important to devote much time to locomotor development since most Down's syndrome children eventually walk and move easily" (p. 385). Although these authors claim progress in all other areas of development, locomotor skills did not show any improvement.

A number of authors claim significant gains in motor skill after remedial programs (Smeets and Manfredini, 1973; Connolly and Russell, 1976; Hughes, 1971; Kugel, 1970). None of these authors included any statistical analysis to support their findings. Studies designed to determine the efficacy of early intervention programs are therefore necessary. The unknown aspects of Down's syndrome combined with the information available regarding the detrimental factors combine in such a manner that

> ". . .rather than spur clinical research to elucidate the challenges which are present, has often been ignored in favour of the previously noted professional posture of

> hopelessness, and questions about future attainments are commonly 'answered' by suggesting prompt institutionalization to parents. The lack of knowledge concerning developmental potentials and projection of the professional's own negative attitudes toward the infant with Down's syndrome can adversely influence the child and his future opportunity to develop" (Menolascino, 1974, p. 15).

One of the unknown elements is the influence of height and weight or size for age on the attainment of motor skills. Anthropometric data has been collected by several authors when studying motor performance of Down's syndrome children. Bruininks (1974) reports that this group has been found to be smaller on measures of linear growth and skeletal age. Stedman and Eichorn (1964) found that there was a significant difference in the height of their home-reared group versus institutional groups, the major difference being in greater leg length of the home-reared children, who also walked earlier than their institutionalized cohorts. After the age of six months, leg length was one of the factors in Bayley's (1935) study which showed positive correlation to age at which normal children walked and engaged in pre-walking behavior (crawling and creeping).

Centerwall and Centerwall (1960) recorded heights and weights of their sample, but no statistical analysis was undertaken. Stedman and Eichorn (1964) computed from their data that "trends were consistent with infant groups" (p. 398), the home-reared group being significantly taller and heavier than the institutionalized group.

Stedman and Eichorn (1964) see early walking abilities of home-reared groups as a possible cause of greater height. Those children who engaged in walking were actually providing stimulation to growth centres of bone through use of muscles and joints, more rapid bone growth being stimulated by increased vascularization. An increase in muscle

bulk was also noted in calf muscles of early walkers. Height and weight for age has been found to influence attainment of milestones (Bayley, 1935). Whether size also influences the performance of motor skills should be investigated.

In summary, although slow attainment of milestones such as sitting, crawling, and walking is often a consistent pattern of motor development for the mentally retarded (Illingworth, 1975), the Down's syndrome child presents a series of special problems associated with motor development. The most marked of these deviations is the degree of hypotonia consistently present in these children.

Various theories have been proposed in an attempt to explain this deviation from normal developmental patterns. Frith and Frith (1974) approach the problem from a motor learning perspective. Cowie (1970), Donoghue et al. (1970), and others suggest a neurological deficit. Cowie suggests that the hypotonia in these children is associated with a maturational delay specifically in the cerebellum. Donoghue et al. hypothesize lesions in lower centres of the brain, including the cerebellum, midbrain and basal ganglia, as well as deficits in cortical control.

Deficits in motor development in Down's syndrome children, regardless of the precise etiology, appear to hamper the child, causing difficulty in the investigation of his environment, limiting his capacity for independent movement in such a way that it may further hamper development of cognitive processes by depriving the child of early experiential learning.

When these children do eventually assume the upright position, the postural components of their gait patterns frequently appear so defi-

cient that they may hamper further development of co-ordination, speed and agility. These patterns also contribute to setting the Down's syndrome child apart from his peers as he automatically appears different by virtue of his unusual gait.

As shown in Table II, the age of attainment of milestones such as sitting, crawling and walking varies greatly among the Down's syndrome population. The amount of variance within the population, as well as between individual children, has made assessment difficult and normative assessment instruments inappropriate, especially when information from these assessments is to be used for remedial programming purposes.

Motor development and deafness: Little information has been reported in the literature regarding the influence of sensory deprivation on motor development in the case of the hearing-impaired. In the early 1930's, studies by Long (1932) and Morsh (1936) indicated that deaf children performed equally as well as hearing children in manual and fine motor skills, but were significantly below the hearing children in tests involving balance skills. These findings were later confirmed by Boyd (1967) and Myklebust (1960) who conducted several studies involving static balance skills and found, amongst other things, that in general, deaf children were inferior to the hearing children in both static and dynamic balance. Myklebust also indicated that deaf boys were superior to deaf girls, and that children whose deafness was due to exogenous causes did more poorly than any other group of deaf children assessed.

Boyd's (1967) work indicates that the deaf were inferior in balance skills but equal in "speed on eye-hand co-ordination tasks"

(p. 598). Regardless of the cause of deafness, he found balance "deficiencies equally distributed" (p. 600). Boyd's findings indicate that children deafened by endogenous causes "perform and develop in a manner relatively similar to the hearing" (p. 602), while those deafened prenatally and by exogenous causes exhibited the poorest performance levels "and also a slower rate of [motor] development" (p. 602). Lindsay and O'Neal (1976) partially support Boyd's (1967) findings: they found that eight year old deaf children demonstrated "deficient abilities in static balance skills" (p. 53). As well, deficiences in "locomotor co-ordination or dynamic balance skills" (p. 53) were found when compared to hearing eight year olds. One explanation for the differences between Boyd's findings and those of Lindsay and O'Neal may lie in the fact that the research design employed by the latter did not control for cause of deafness.

Boyd (1967) was careful to separate his sample groups according to etiology of deafness. The research designs reported have usually controlled for variables such as age, sex, residential status and degree of hearing loss, but have not controlled for etiology. It is frequently difficult to obtain accurate information regarding the cause of deafness, as school records often contain only a questionnaire completed by parents or guardians and answers to those items referring to cause of deafness are frequently unknown. When the cause of deafness varies amongst children who are studied in one group, a false impression is likely to be conveyed when the performance of the deaf sample is compared to a hearing sample -- the deaf group always shows a poorer performance. This same issue was also poorly handled by Case, Dawson, Schartner and Donaway (1973), who compared levels of "fundamental skill" (motor skill) between

blind, deaf, and non-handicapped high school age boys. These authors state that they recognize that etiological factors contribute to the degree of motor skill proficiency, but they did not control for this variable in the design of the study.

In a study designed to assess "gross motor ability" using the Brace Motor Ability Test, Carlson (1972) selected deaf children between the ages of five and ten years of age, classified according to degree of hearing loss. No difference was found between the three groups, suggesting that "intensity of hearing loss does not affect balance and/or motor ability" (p. 305). Little difference was found between the gross motor abilities of boys and girls, contrary to Long's (1932) findings.

Case et al. (1973), using the same test as Carlson (1972), assessed the motor abilities of 14 and 16 year old deaf, blind and unimpaired males. Advanced locomotor skills involving "balance, flexibility, co-ordination, directionality and strength" (p. 1292) were assessed: no difference was found between the groups on tests involving strength. Their findings support Myklebust's (1960) contention that the deaf subjects' area of greatest difficulty was balance, "due to damage of vestibular mechanism associated with etiology of deafness" (p. 1291). Fitzgerald, Sitton and McConnell (1970) state that the "literature indicates that mental and physical development as well as hearing, of rubella children are often affected" (p. 220), the term "rubella children" referring to a fetus exposed to rubella virus generally contracted by the mother during the first three months of pregnancy. In their sample of 19 subjects between three years, eight months and three years, eleven months of age, motor development was "normal" despite a deviation in physical size. Mean age of first crawling was 7.6 months and indepen-

dent walking was 12.6 months, "slightly advanced in crawling behavior according to Gesell's norms" (p. 227). Barr and Lundstrom (1961) report on comparing rubella infants with other deaf infants, that the rubella group showed arrested development which was not attributable to their hearing loss. Lundstrom (1962) and Fitzgerald et al. (1970), in a follow-up study, found "first trimester rubella. . .children were shorter and weighed less than did control group children and that this underdevelopment continued to be more evident at three years of age" (p. 219). First trimester rubella children are defined as deaf infants who, during the first three months of the gestation period, were subjected to the effects of rubella, due to the mother contracting the disease. Myklebust (1960) also found the motor performance of deaf, mentally retarded children within an elementary school population to be significantly below that of other deaf children within that group. The etiology he attributed to deafness in those cases was exogenous, such as maternal rubella.

Zausmer (1971) found a positive relationship between scores obtained on an assessment of motor development "and the gestational time at which the rubella infection occurred" (p. 21). Analysis of scores on items measuring equilibrium also showed a positive relationship. Maternal rubella contracted between the fifth and eighth weeks of pregnancy was associated with the best motor performance of the group, while the lowest total scores, reflecting the poorest performance, were obtained by those infected within the first four weeks of gestation. Zausmer's results support her hypothesis "that motor deficits in children with congenital rubella can be attributed to damage at specific stages of embryologic development when the most important structures involved in

a particular motor activity are in their most crucial stage of organization and differentiation" (p. 25).

Another problem encountered in studies concerning deaf children is the necessity for researchers conducting large studies to select their sample populations from a residential population. It is customary for most schools for the deaf, both in Canada and the United States, to be residential. Therefore, when groups of deaf children are compared to one another, the research design is one in which residential status can be controlled.

King, Raynes and Tizard (1971) showed in their study involving the management practices in institutional settings for unimpaired, mentally retarded, and chronically ill children, that the child-oriented practices of the personnel caring for children were not dependent on numbers of children, size of institution, or degree of handicap, but largely on the educational background and orientation of the unit supervisor.

Ten to 15 years ago administrators in schools for the deaf ran a tightly-controlled, regimented, isolated institution which to all intents and purposes was a community in itself. Students now in early adolescence are products of these institutionally-oriented systems and are being included in recently reported studies such as that of Case et al. (1973), and compared to non-institutionalized or non-residential school hearing peers. Therefore, differences found between the performance of hearing and hearing-impaired children on motor tasks may be affected by the long term residential school status of the hearing-impaired. The hearing subjects may have the advantage of greater freedom of movement over a longer period of time.

Summary

Extensive studies of normal motor development have been undertaken and considerable longitudinal data amassed concerning milestone attainment and advanced locomotor skill development. The purpose behind early studies in the motor area was to compile normative data which could be used in the development of norm-referenced testing instruments. Results of these assessments enabled the comparison of a subject's motor abilities with his peers, providing information regarding his relative standing within the normative sample. Criterion-referenced testing of motor development provides information about the subject's performance which can be directly related to intervention programs by indicating a starting point for instruction. It is suggested by the authors of criterion-referenced tests that knowledge of what the child can actually do is essential to the construction of early intervention programs. The child's relative standing within a group is of little assistance to curriculum development.

Literature pertaining to the motor development of mentally retarded and hearing-impaired children indicates that the diagnostic categories of Down's syndrome and prenatal exogenous deafness usually involve deficits in motor development. Milestone attainment in both groups has been found to be affected, especially in children exhibiting Down's syndrome. Similar deficits in advanced locomotor skills involving equilibrium and balance areas have been noted in both groups.

On comparing Table I (Age of Milestone Attainments in Unimpaired Children) to the data in Table II (Age of Milestone Attainments in Down's Syndrome Children), it is apparent that Down's syndrome can interfere markedly with motor development. In none of the studies re-

viewed in Table II does a Down's syndrome child walk before the age of 22 months, and comparable delays in sitting, crawling and standing are evident. Similar studies of milestone attainments by deaf children were not found. However, Myklebust (1960) reports that age at sitting and walking is within normal limits. The likelihood of co-ordination, motor balance and motor speed being affected is significantly increased in prenatally deaf children who have been exposed to maternal rubella or those who contracted meningitis. It has been found that locomotor activities requiring the maintenance of the upright posture and equilibrium are most frequently affected by maternal rubella.

A great deal of difficulty is encountered in the assessment of the young deaf child when the assessment instrument requires the comprehension of verbal instructions. Deaf children are frequently penalized by their inability to understand test instructions as opposed to their inability to perform the task or respond appropriately. As both the Down's syndrome and some groups of hearing-impaired children demonstrate difficulties in acquisition and/or performance of motor skills, it is reasonable to validate an assessment device that will not penalize either group. A criterion-referenced approach offers an assessment device which yields information about the level of mastery of specific motor tasks. Information regarding areas of deficit and areas of mastery can be directly related to remedial programming and provide starting points for such a program. The criterion-referenced assessment devised by Kysela et al. (1976) relies on single words or short phrases for instructional purposes. It has a mechanism whereby demonstration or modeling can be employed by the examiner and requires a successful completion on two out of three trials on each item. This allows the deaf

child an opportunity to see what is required in a task and still attain a maximum final score. This assessment device is the most detailed assessment of motor abilities available. It is suitable for use with the retarded and hearing-impaired populations. It meets the requirements outlined by Gronlund (1973) and Baine (1977) regarding the definition of behavioral objectives from a clearly delineated task domain, adequately sampled items which are included because of their relevance to the terminal objective, and finally a scoring and reporting system which describes the child's performance adequately on clearly defined tasks. A validation study of this instrument and the proposed sequence of objectives should therefore be completed.

CHAPTER III

RESEARCH QUESTIONS

In devising any scale it is important to ascertain if the universe of items is scalable. "The universe is said to be scalable for the population if it is possible to rank the people from high to low in such a fashion that from a person's rank alone we can reproduce his response to each of the items in a simple fashion" (Guttman, 1947, p. 249). Scalability may be possible for one population and not another, or a sub-population and not the entire population (Guttman, 1947; Stouffer, Guttman, Suchman, Lazarsfeld, Star and Clausen, 1950). In this case it is necessary to ascertain the scalability of the domain of motor development as represented by the sequence of items on the Criterion-Referenced Assessment Guide -- Motor Development (CRA-MD) (Kysela et al., 1976) (see Appendix A). For these purposes a perfect scale would be indicated if a subject passed an item of given difficulty and also passed any item of lesser difficulty. Conversely, any subject who fails an item of given difficulty will also fail items of greater difficulty. The level of difficulty for each item within the sequence of items on the CRA-MD will determine its place within that sequence. Information regarding the scalability of this assessment device will indicate the ordinality of the proposed sequence of terminal and enabling objectives in relationship to the three major component area; postural maintenance, postural assumption, and locomotion/movement. Ordinality pertains to the sequencing of objectives in their order of complexity or in accordance with the level of difficulty of each item. The proposed sequence must therefore be tested.

In the construction of the CRA-MD, the Portage Guide (Shearer and Shearer, 1972), as well as developmental indices taken from scales of growth, were used to derive the developmental sequence in which motor skills were acquired by a normative population. This normative data provided guidelines for the sequencing of terminal and enabling objectives. Enabling objectives were organized in a logical sequence according to their degree of difficulty; whether they are scalable or ordinally sequenced remains to be studied.

The sequencing of terminal and enabling objectives proposes a step-by-step progression from simple to complex, mastery of each sub-skill being in some way developmentally associated with the acquisition of previously mastered skills. This relationship may be such that one skill is not totally dependent upon the other so as to be a prerequisite to mastery of the terminal objective, but related to it in such a way that it is indeed part of the sequence of enabling objectives necessary for the performance of the highest level of skill being tested.

Performance on each of the first seven motor areas of the CRA-MD was examined separately, using one of the two standard statistics for measuring scalability (Rogers, 1977). Guttman's coefficient of reproducibility (Guttman, 1947, 1950) was found to be the most suitable, as the other, Green's index of scalability (Green, 1956), required dichotomous items.

Guttman's scaling method is referred to as the Cornell Technique for scalogram analysis (Guttman, 1947). This method is intended to determine whether a scale exists. A perfect scale in Guttman's sense is one in which an individual passing items of given difficulty will also pass any item of lesser difficulty. Conversely, an individual who fails

an item of given difficulty will also fail any item of greater difficulty (Angoff, as in Thorndike, 1971, p. 529). The amount by which a given scale deviates from the ideal pattern is measured by the coefficient of reproducibility. In this study the coefficient represents the degree to which the sequence of objectives is followed by the subjects.

Reproducibility alone is not a sufficient test for scalability. Although it is the principal test, Guttman states that four other features must also be taken into account: "(a) the range of marginal distribution, (b) pattern of errors, (c) number of items in the scale, (d) number of response categories in each item" (Guttman, as in Stouffer et al., 1950, p. 78). The CRA-MD, by virtue of the hierarchical sequencing of objectives, accounts for each of these features. Scalability is considered to be attained if there is "about 90% reproducibility": not more than 15% error in all responses should be accepted (Guttman, 1947, pp. 250-256). Ninety percent reproducibility refers to the attainment of coefficients of reproducibility which are not lower than .90. The 90% level of reproducibility will therefore be adopted as the level necessary to indicate scalability.

The major research question is therefore to ascertain the scalability of the proposed sequence of items on the CRA-MD. Estimates of the degree of reproducibility present in data will also be made. The data will be collected by assessing a heterogeneous group of children randomly selected from a subject pool containing individuals from some diagnostic categories which have been shown to influence the acquisition and performance of the motor skills under investigation.

The first research question should therefore deal with the scalability of the terminal objectives as they relate to the three major

component areas of the CRA-MD.

> I. Given a heterogeneous group of children between the ages of two and six years, the proposed sequence of terminal objectives will be assessed for scalability under the three major component areas: postural maintenance, postural assumption, and locomotion/movement. The objectives will be considered scalable if 90% coefficient of reproducibility or better is established in each area.

The second research question will deal with the scalability of the sequence of enabling objectives within the seven motor areas: controlled eye movements, head control prone, head control supine, rolling, sitting, crawling, and walking.

> II. Given a heterogeneous group of children between the ages of two and six years, the proposed sequence of terminal and enabling objectives will be assessed for scalability within each motor area. The terminal and enabling objectives will be considered scalable if 90% coefficient of reproducibility or better is established in each area.

The third research question will deal with the relationship between anthropometric measures (height and weight) and the attainment of the objectives in the three major component areas of postural maintenance, postural assumption, and locomotion/movement.

> III. Given a heterogeneous group of children between the ages of two and six years, the degree of association between scores attained on the CRA-MD and anthropometric measures, height and weight, will be ascertained. An association or correlation will be indicated if the results of the Spearman rank correlation coefficient are significant at $P = .05$ level.

CHAPTER IV

METHOD

Subjects

Fifty subjects, 24 females and 26 males between the ages of two and six years, were randomly selected from three Edmonton preschool programs (total N = 75). All programs are situated in the metropolitan area. Each program provides instruction to one of three different groups of children: (1) children with Down's syndrome, from the Early Education Project, Mayfield School; (2) hearing-impaired children, from the Association for the Hearing Handicapped Preschool; and (3) non-impaired children attending a day-care setting, Downtown Day-Care Centre.

Down's syndrome subjects were defined as those children so diagnosed by their physician at or soon after birth, who were currently enrolled in the Early Education Project at Mayfield School. Hearing-impaired subjects were defined as those children "whose hearing loss has precluded normal acquisition of language" (Myklebust, 1960, p. 4). This degree of hearing loss, 85 decibels or greater, has made it necessary for these children to attend a preschool for the hearing-impaired as opposed to regular kindergarten or day-care settings. Unimpaired subjects were defined as those children attending a day-care program on a daily basis, who have not been identified by their teacher, physician or family as having any special educational needs to date.

As the object was to determine the validity of the Criterion-Referenced Assessment Guide -- Motor Development and the ordinality of the terminal and enabling objectives, it was necessary to establish entry level performance skills for this heterogeneous group. Consequently, the

highest level or most complex behavior being assessed was selected: Item 7C -- walking in a co-ordinated fashion (see Appendix A). Mastery of this terminal objective with a high performance proficiency rating would indicate that the subjects' entry levels were equal in terms of milestone attainment. Children included in the validation study were selected from a pool of fifty subjects on the basis of their ability to demonstrate mastery: that is, attain a high performance proficiency on Item 7C. A total of 26 subjects attained performance proficiency on this item.

Table III outlines the selection of the heterogeneous group. Four subjects were deleted from the unimpaired portion of the sample. Two were Spanish-speaking and had an insufficient command of English to follow directions. The other two, although able to maintain balance when walking, failed to demonstrate reciprocal arm-swing and heel-toe gait patterns necessary to fulfill the criteria of Item 7C. Twelve subjects were deleted from the Down's syndrome portion of the sample as they displayed similar problems as those deleted from the unimpaired group who were unable to fulfill the criteria for Item 7C. Two more subjects were deleted from the Down's syndrome portion of the sample as they were unable to walk without assistance. Two subjects were deleted from the hearing-impaired portion of the sample, because they resided in rural areas served by a visiting home teacher and did not attend regular day programs as did the other subjects.

The random sampling was completed during March 1977 and testing undertaken during April and May 1977. During that time period, four subjects withdrew from the day-care program.

TABLE III

SELECTION OF SAMPLE GROUP (N = 75)

	Down's Syndrome	Hearing Impaired	Unimpaired Group	Subjects
Random Selection	16	7	27	
Did not pass Item 7C	(14)	(0)	(2)	
Spanish speaking: command of English not sufficient to follow directions	(0)	(0)	(2)	
Did not regularly attend program: residing in rural area served by home teacher	(0)	(2)	(0)	
Withdrew from program during test period	(0)	(0)	(4)	
	(2)	(5)	(19)	26

Instrument: Criterion-Referenced Assessment Guide -- Motor Development

Motor performance was assessed using the Criterion-Referenced Assessment Guide -- Motor Development (CRA-MD) devised by Kysela et al. (1976). This instrument provides detailed information regarding the subject's level of performance on three motor components: postural maintenance, postural assumption, and locomotion/movement. The CRA-MD is designed to assess the following areas of motor performance:

1. Controlled eye movements
2. Head control prone
3. Head control supine
4. Rolling
5. Sitting
6. Crawling
7. Walking
8. Stair climbing
9. Running
10. Sitting motions and activities
11. Hopping
12. Advanced locomotion

Ordinality of the first seven areas will be tested in this study. The testing procedure entails six levels of prompting or assistance, the amount of prompting or guidance provided by the examiner increasing at each level. Completion of a task at level 5, the highest level attainable, requires approriate performance without any prompting following the initial instruction. At level 4, verbal prompting (repetition of the original instruction or a statement designed to focus the child's attention on the salient features of the task) is employed if, after 5 seconds following the original instruction, either no response or an incorrect response is made.

At level 3 physical prompting is provided 5 seconds after the level 4 prompt. Physical prompts are defined as gestures such as pointing made by the examiner in order to elicit appropriate behavior or focus attention. Modeling or demonstrating the task for the child is

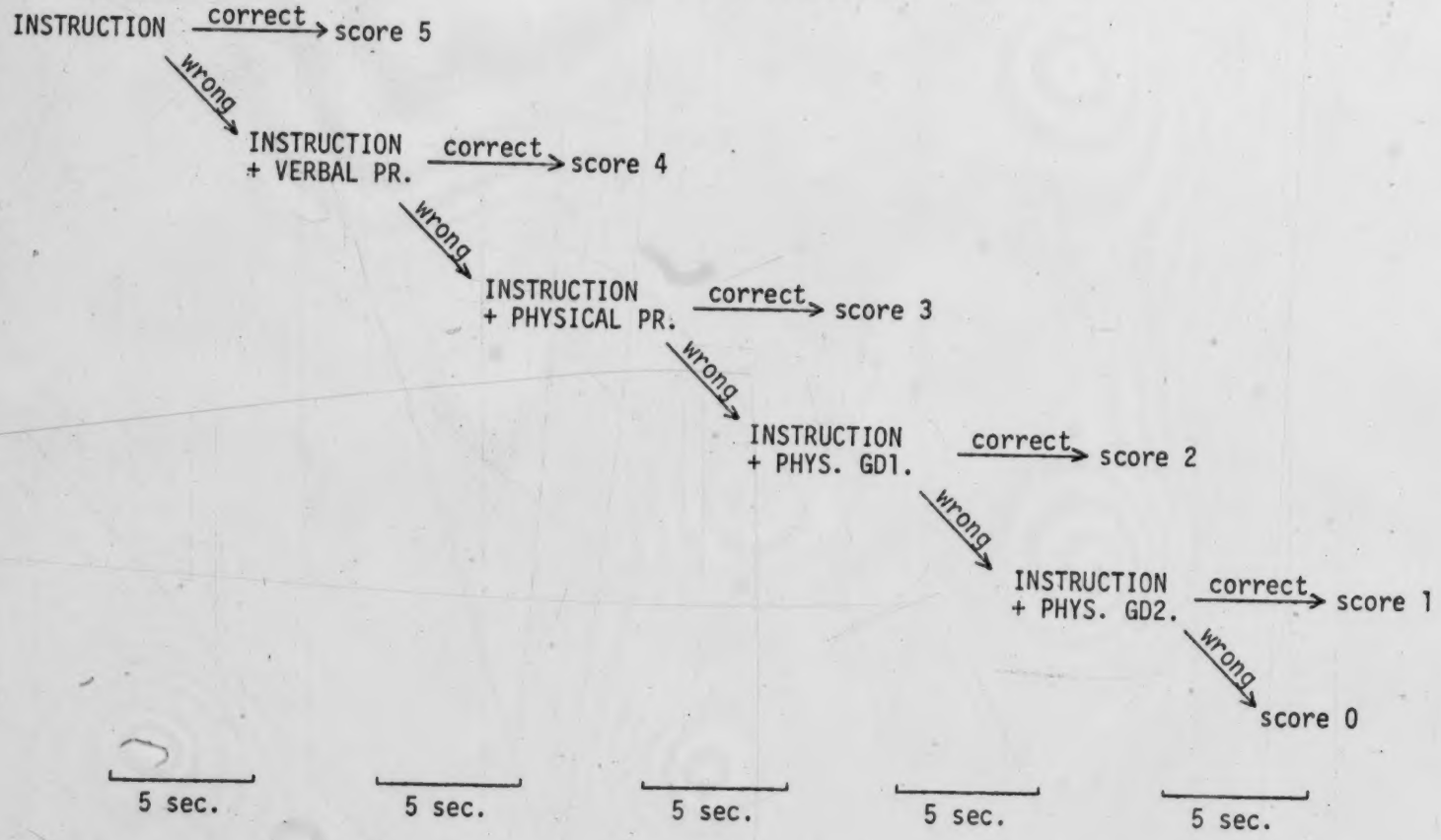
considered a level 3 prompt. No actual physical contact is made between the examiner and the child at this point. Level 2 prompts take the form of minimal physical guidance. If an incorrect response, or no response, is made within 5 seconds of a level 3 instruction, the examiner initiates physical contact with the child: this may entail one-finger guidance for a period of no more than 5 seconds. Level 1 prompts are provided after 5 seconds if no response, or an incorrect response to a level 2 prompt occurs. Physical guidance provided at this level takes the form of hands-on guidance for a period of 5 seconds, or putting the child through the activity passively. Level 0 is recorded if the task is not performed correctly following a level 1 prompt.

Figure 1 outlines the assessment procedure, showing how the levels of prompting are employed. This procedure is instituted for three successive trials on each objective. Items are scored according to the level at which mastery is achieved on each trial. The lowest or most frequently attained level for the three trials comprises the final score, or "performance proficiency rating". This overall proficiency rating is intended to indicate the stability of each behavior within the child's repertoire of skills. It is therefore used to indicate the initial teaching level applied when commencing remedial programming (for teaching purposes instruction begins at the level attained by the child and progresses through to level 5: assessment, however, begins with level 5 and progresses down to level 1, hence the term "test-teach model").

The rationale for commencing the remedial instruction at the level indicated by the performance proficiency rating is that if the child can perform a level 3 prompt (demonstration), then it is unneces-

FIGURE 1

CRITERION-REFERENCED ASSESSMENT GUIDE -- MOTOR DEVELOPMENT*
ASSESSMENT PROCEDURE



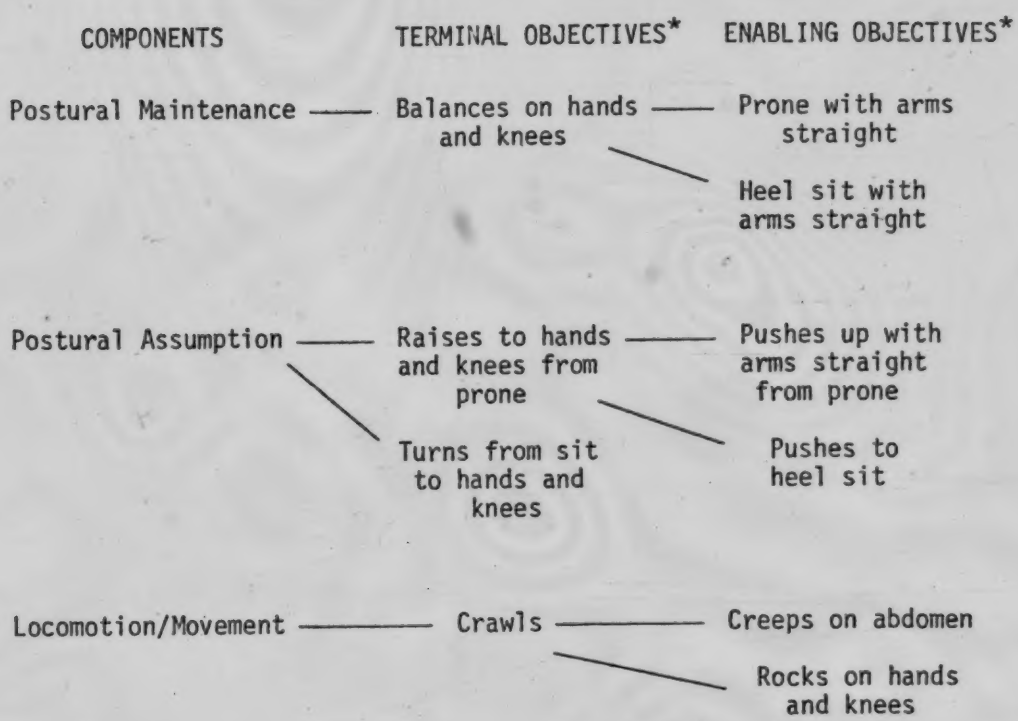
*Kysela et al. 1976.

sary to commence instruction at a lower level of remedial intervention. The scoring system assumes that a degree of consistency is shown by a 2-4-4 performance over three trials, probably reflecting the child's actual level of skill or competency to be level 4. However, a 2-4-3 over three trials reflects instability, and in this case it is likely that level 2 instructional prompts are the more valid estimate, while the higher, varied scores may be happenstance.

The CRA-MD assessment provides detailed information regarding the subject's level of performance on the components of postural maintenance, postural assumption, and locomotion/movement. In each of the areas of motor performance included in the assessment, terminal objectives represent the highest level of performance in each component. Enabling objectives, or sub-skills, leading to the terminal objectives are arranged hierarchically from simple to complex, and are prerequisite to the mastery of the terminal objectives (see Figure 2). As an example, Figure 2 outlines the relationship between the component areas, terminal objectives, and enabling objectives as they pertain to the motor area "crawling". The assessment procedure when using this instrument is to administer the terminal objective in each area: the enabling objectives are assessed only when mastery of the terminal objective is not demonstrated at level 4 or level 5. In this instance, in order to test ordinality of the sequence of terminal and enabling objectives within the first seven motor areas, each of the objectives will be administered regardless of the performance proficiency rating gained on the terminal objective in each category.

FIGURE 2

MOTOR AREA "CRAWLING"



*See Appendix A for complete behavioral objective

Anthropometric Measurements

Height and weight were measured using a normative procedure, recorded heights and weights being converted to percentile ranks, as the literature suggested that size for age variables may affect a subject's ability to perform gross motor skills. Height was measured using the Metric Height Chart devised by Reese (1974). Scores were recorded using anthropometric charts reproduced by Children's Medical Centre, Boston and percentile ranks determined according to that scale. Weight was measured using a set of metric portable scales, and recorded using anthropometric charts reproduced by Children's Medical Centre, Boston. Percentile ranks were determined according to that scale.

Procedure

Two short test sessions were undertaken with each child on an individual basis. If the child was able to walk without losing his balance, using a heel-toe gait, and having reciprocal arm-swing opposite to the "heel-strike" foot, he was considered to have demonstrated mastery of Item 7C (see Appendix A). The height of the child was measured in standing position using the Metric Height Chart (Reese, 1974). Weight was also measured at this time, using a set of metric portable scales. The indicator of the scales was set at zero before each measurement was taken. The subjects were assisted to stand on the scales with feet hip-distance apart, trunk straight and arms held in a relaxed position by the sides. Each subject was told to look straight ahead and focus on a point at eye level on the wall directly in front of him. All instructions to hearing-impaired subjects were provided using a total communications approach which requires the combined use of speech and manual

communication, or sign language. The first testing session took no more than 10 minutes and enabled the subject and the examiner to meet in a situation which was not threatening to the child. Each subject was then informed that he or she would return to work with the examiner later that week for a period of 30 minutes.

At the second testing session the first seven items of the CRA-MD were completed, commencing with the first terminal objective in Item 1 and including all enabling objectives administered in the order outlined on the CRA-MD Guide. Three trials in succession were given and the level attained recorded on the guide (see Appendix A). All terminal and enabling objectives were assessed in this manner.

Equipment required to complete this assessment included one kindergarten chair with a seat height of 30 cm., one stool with a seat height of 35 cm., and a flexible hose 60 cm. in length. As well, five small toys which could be easily grasped with one hand and were interesting to the age group involved were used, three animals and two cars.

All testing was carried out in a carpeted area separated from the rest of the activity being carried out in the regular program.

Observational Reliability

In order to avoid such errors as observer expectancy influencing data collection when using the CRA-MD, a reliability check was made prior to data collection and during data collection, in order to establish inter-rater reliability and maintain reliability on dependent measures.

Videotaped CRA-MD assessments of three children available to the author were rated by an independent trained reviewer and the author.

The reliability coefficient was calculated as outlined by Sulzer and Mayer (1972):

$$\frac{\text{No. of agreements}}{\text{No. of agreements + no. of disagreements}} \times 100 = \%$$

with a reliability coefficient of no less than 80% being the required level. Reliability coefficients were computed using performance proficiency ratings for terminal and enabling objectives in each area, and results are as follows:

Motor Area 1 - Controlled Eye Movements	98.2
Motor Area 2 - Head Control Prone	100.0
Motor Area 3 - Head Control Supine	100.0
Motor Area 4 - Rolling	100.0
Motor Area 5 - Sitting	100.0
Motor Area 6 - Crawling	100.0
Motor Area 7 - Walking	100.0

Procedural reliability was assessed during the collection of the data in an effort to ensure that the CRA-MD continued to be administered in the required manner. Videotaped CRA-MD assessments of three children chosen at random from the target population were rated blind by one independent reviewer (previously used) and the author, a procedural reliability coefficient (calculated as outlined above) of no less than 80% being the required level. Reliability coefficients were completed using performance proficiency ratings for terminal and enabling objectives in each area, with results as follows:

Motor Area 1 - Controlled Eye Movements	100.0
Motor Area 2 - Head Control Prone	100.0
Motor Area 3 - Head Control Supine	100.0
Motor Area 4 - Rolling	100.0
Motor Area 5 - Sitting	95.1
Motor Area 6 - Crawling	95.1
Motor Area 7 - Walking	98.2

Design

As scalability of the Criterion-Referenced Assessment Guide -- Motor Development forms the basis of the research questions, the Cornell Technique of scalogram analysis devised by Guttman (1947) will be employed to establish the scalability and percent reproducibility of the CRA-MD sequence for objectives one to seven. This assessment device meets the requirements outlined by Guttman (1947): (1) data is on an ordinal scale; (2) there are sufficient items to obtain both a uniform frequency distribution on some items as well as non-uniform distribution of responses (performance levels) on others; (3) no category contains more error than non-error -- i.e., in no unit of terminal and enabling objectives is the number of subjects failing to follow the proposed sequence greater than the number who attain the objectives in the order proposed; (4) not more than 15% of responses in any sequence violates the proposed hierarchy; and (5) sufficient categories of response or levels of performance within each objective provide adequate opportunity for scalability error to occur should it exist.

Guttman's method of analysis proposes that a measurement of the internal consistency of a rating scale provides evidence that the different items on that scale are representative "of different quantitative positions on the same basic dimension" (Hayes, 1967, p. 70). The results of this scalogram analysis provide a "coefficient of reproducibility" which is indicative of the percent accuracy with which responses can be reproduced from total scores. The 90% level of reproducibility will be considered indicative of scalability; any less than that level will be rejected as not constituting a true scale.

Skills by subject matrices will be used to rank-order subjects

according to their performance on each item. Scalogram analysis was employed to ascertain the percent reproducibility or the "coefficient of reproducibility" for the sequence of terminal and enabling objectives as outlined in the research questions.

> Research Question I: The proposed sequence of terminal objectives will be analyzed for scalability within the three major component areas, postural maintenance, postural assumption, and locomotion/movement (for items 1 - 7 only).

> Research Question II: The proposed sequence of enabling objectives will be analyzed for scalability within each motor area (areas 1 - 7 only).

Scalability was attained if a 90% coefficient of reproducibility or better was established on each of the above.

In order to determine the degree of association between two sets of scores, the anthropometric measures and the levels attained on the CRA-MD for this heterogeneous sample, it was necessary to determine a correlation coefficient. In this instance a non-parametric statistic was required as the data available did not meet the assumptions necessary for use of parametrics, interval scale data was available on one variable only, CRA-MD scores being ordinal data. Spearman's rank order correlation coefficient (as in Siegel, 1956): r_s (or rho), a non-parametric rank order correlation method, was employed.

> Research Question III: The degree of association between the anthropometric measures height and weight and the scores attained on the CRA-MD will be ascertained.

A correlation coefficient was considered statistically significant if the obtained value exceeded the critical value for the .05 level of significance.

CHAPTER V

RESULTS

The results of this study were analyzed according to the research questions presented previously in Chapter III. In order to assess the degree of scalability present within the first seven motor areas of the Criterion-Referenced Assessment Guide -- Motor Development (CRA-MD, Kysela et al., 1976), scalogram analysis was employed. The Cornell Technique as outlined by Guttman (1947, pp. 247 - 279) was used. Scalability was assessed for the sequence of terminal objectives within each of the three major components: postural maintenance, postural assumption, and locomotion/movement. Terminal and enabling objectives within each of the seven motor areas were also assessed for scalability according to the three component areas. The results of each research question will be discussed individually.

The degree of association between the anthropometric measures (see Appendix B) of height and weight for this heterogeneous sample was tested using the Spearman rank correlation coefficient: r_s (Siegel, 1956, pp. 202 - 213). The relationship of these variables to the scores attained on the CRA-MD by this heterogeneous group was also tested using Spearman's r_s. As numerous tied ranks existed in the CRA-MD results, the product-moment correlation for paired observations outlined by Ferguson (1971, pp. 306 - 307) "where average ranks have been substituted for ties" was applied. The difficulty arising with numerous tied ranks is that ranks are considered to be equal to the number of observations, but with tied ranks this is no longer the case. The sum of squares of the ranks will be at variance with the sum of squares of the first N

observations and will therefore influence the value of the correlations finally attained. The degree of association between the anthropometric measures and the three major component areas (postural maintenance, postural assumption, and locomotion/movement) was tested in this manner. Results of the analysis of anthropometric data will follow the discussion of Research Questions I and II.

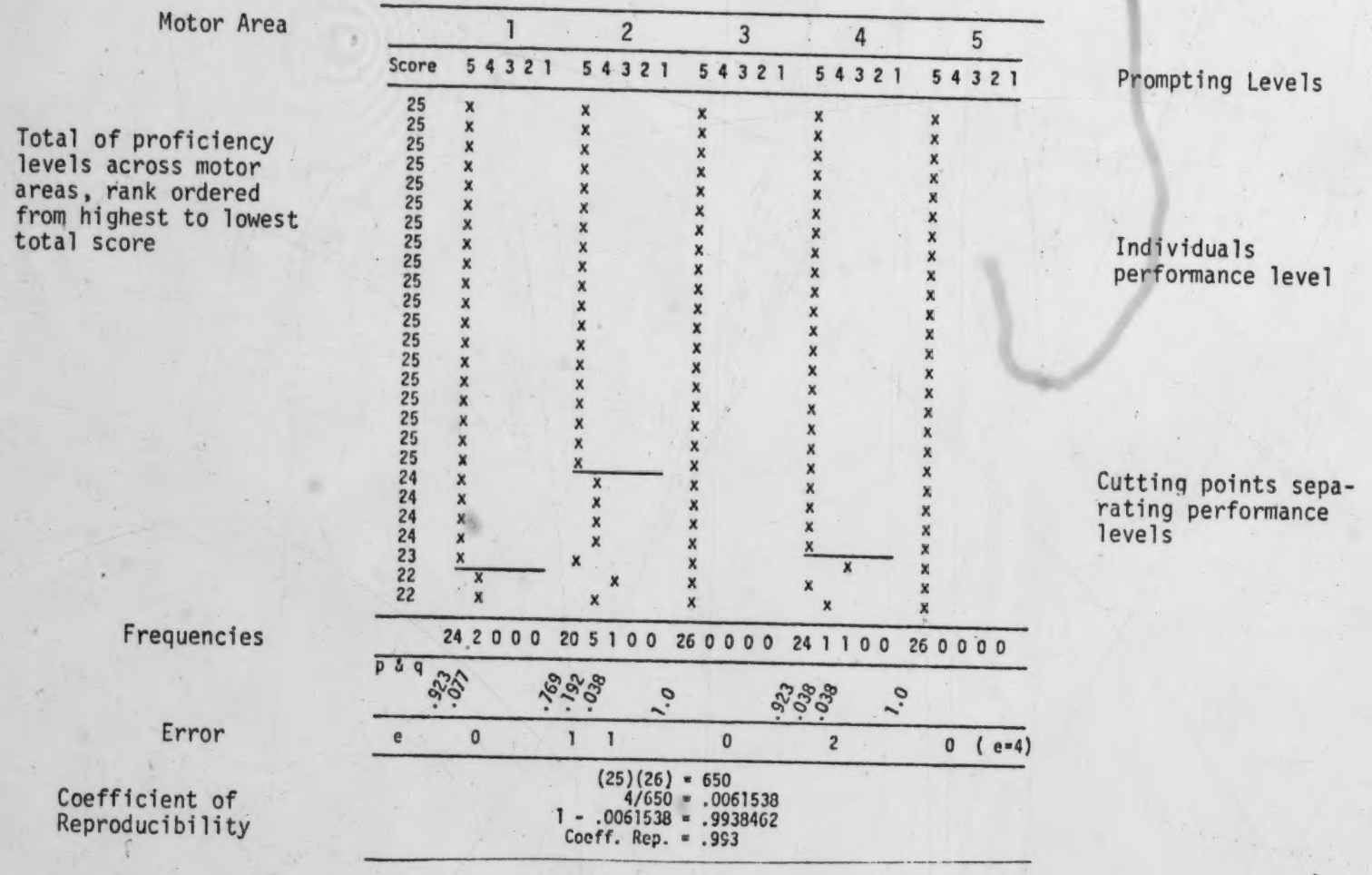
In order to assess scalability, a skills by subject matrix was prepared for each component. This item-response matrix is produced from raw data; it contains "a row for each respondent and a column for each item-response category. An entry in the matrix indicates whether a particular respondent gave a particular item response" (Green, 1956, p. 79). The responses were rank ordered according to total scores and arranged in the matrix from high to low. The level of performance for each subject is indicated on the table by an "x" in his row in the column for each category into which he falls. Figure 3 illustrates the composition of the skills by subject matrices used throughout. The top line refers to motor areas being analyzed within the matrix. The prompting levels 5 to 0 are shown directly below. The scores recorded in the first column refer to the total performance level obtained across the motor areas. Cutting points are inserted within the rank ordering of each column of responses in order to separate them according to categories in which they would fall if the scale were perfect.

At the base of the figure frequencies of response in each category are recorded.

"P & Q" refers to the probability of the sequence of responses being scalable, P = 1.0. The amount of error (e) is recorded for each category and summed. The coefficient of reproducibility is derived by

FIGURE 3

COMPOSITION OF SKILLS BY SUBJECT MATRICES


Motor Area
1 2 3 4 5
Score 5 4 3 2 1 5 4 3 2 1 5 4 3 2 1 5 4 3 2 1 5 4 3 2 1
Prompting Levels
Total of proficiency levels across motor areas, rank ordered from highest to lowest total score
Individuals performance level
Cutting points separating performance levels
Frequencies
24 2 0 0 0 20 5 1 0 0 26 0 0 0 0 24 1 1 0 0 26 0 0 0 0
p & q
.923 .077 .769 .192 .038 1.0 .923 .038 .038 1.0
Error
e 0 1 1 0 2 0 (e=4)
Coefficient of Reproducibility
(25)(26) = 650
4/650 = .0061538
1 - .0061538 = .9938462
Coeff. Rep. = .993

summing the number of responses which would have been predicted wrongly for each person on the basis of the error score, dividing these errors by the total number of responses, and subtracting the resulting fraction from 1. "An acceptable approximation to a perfect scale has been arbitrarily set at 90 per cent reproducibility" (Guttman, as in Stouffer et al., 1950, p. 77).

Research Question I

The first research question pertained to the scalability of the terminal objectives in each of the major components of the assessment device. The research questions are quoted as they appeared in Chapter III. Question I is as follows:

> Given a heterogeneous group of children between the ages of two and six years, the proposed sequence of terminal objectives will be assessed for scalability under the three major component areas: postural maintenance, postural assumption, and locomotion/movement. The objectives will be considered scalable if 90% coefficient of reproducibility or better is established in each area.

In order to assess scalability a skills by subject matrix was prepared for each component. The coefficient of reproducibility in each case was found to be above the 90% level: postural maintenance, .984; postural assumption, .992; locomotion/movement, .993. Tables IV, V and VI show the skills by subject matrices for each component area. The motor areas included within each matrix are as follows:

Table IV, Postural Maintenance Component

1. Controlled Eye Movements
2. Head Control Prone
3. Head Control Supine
4. Rolling
5. Sitting
6. Crawling
7. Walking

TABLE IV

SKILLS BY SUBJECT MATRIX FOR TERMINAL OBJECTIVES: POSTURAL MAINTENANCE COMPONENT

	1	2	3	4	5	6	7
Score	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
35	x	x	x	x	x	x	x
34	x	x	x	x	x	x	x
34	x	x	x	x	x	x	x
34	x	x	x	x	x	x	x
33	x	x	x	x	x	x	x
33	x	x	x	x	x	x	x
32	x	x	x	x	x	x	x
32	x	x	x	x	x	x	x
32	x	x	x	x	x	x	x
30	x	x	x	x	x	x	x
24	x	x	x	x	x	x	x
22	x	x	x	x	x	x	x
	25 0 1 0 0	24 2 0 0 0	16 4 6 0 0	22 1 0 1 2	26 0 0 0 0	22 1 0 3 0	23 2 1 0 0
p & q	.96 .038	.923 .077	.615 .153 .231	.846 .032 .038 .115 1.0		.846 .038 .115	.885 .077 .032
e	1	0	6	1 2	0	1 2	1 (e=14)

(35)(26) = 910
14/910 = .0153846
1 - .0153846 = .9846154
Coeff. Rep. = .984

TABLE V

SKILLS BY SUBJECT MATRIX FOR TERMINAL OBJECTIVES: POSTURAL ASSUMPTION COMPONENT

	2	3	4	51	511	61	611	71	711
Score	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
45	x	x	x	x	x	x	x	x	x
44	x	x	x	x	x	x	x	x	x
44	x	x	x	x	x	x	x	x	x
43	x	x	x	x	x	x	x	x	x
43	x	x	x	x	x	x	x	x	x
43	x	x	x	x	x	x	x	x	x
38	x	x	x	x	x	x	x	x	x
37	x	x	x	x	x	x	x	x	x
	25 1 0 0 0	22 3 1 0 0	24 0 0 0 2	26 0 0 0 0	26 0 0 0 0	23 2 1 0 0	22 4 0 0 0	26 0 0 0 0	26 0 0 0 0
p & q	.96 .038	.846 .115 .038	.923	.077 1.0	1.0	.885 .077 .038	.846 .153	1.0	1.0
e	0	4	2	0	0	1	2	0	0 (e=9)

(45)(26) = 1170
9/1170 = .0076923
1 - .0076923 = .9923077
Coeff. Rep. = .992

TABLE VI

SKILLS BY SUBJECT MATRIX FOR TERMINAL OBJECTIVES: LOCOMOTION/MOVEMENT COMPONENT

	2					3					5					6					7				
Score	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
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25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
24	x						x				x					x					x				
24	x						x				x					x					x				
24	x						x				x					x					x				
24	x						x				x					x					x				
23	x					x					x						x				x				
22		x						x			x					x					x				
22		x					x				x						x				x				
	24	2	0	0	0	20	5	1	0	0	26	0	0	0	0	24	1	1	0	0	26	0	0	0	0
p & q	.923	.077				.769	.192	.038		1.0						.923	.038	.038		1.0					
e	0					1	1				0					2					0				(e=4)

(25)(26) = 650

4/650 = .0061538

1 - .0061538 = .9938462

Coeff. Rep. = .993

Table V, Postural Assumption Component

2. Head Control Prone
3. Head Control Supine
4. Rolling
5i. Comes to Sit from Lying
5ii. Sits on Stool from Lying
6i. Raises to Hands and Knees from Prone
6ii. Turns from Sit to Hands and Knees
7i. Stands Up from Chair Unassisted
7ii. Stands Up from Supine Lying on Floor

Table VI, Locomotion/Movement Component

2. Head Control Prone
3. Head Control Supine
5. Sitting
6. Crawling
7. Walking

(see Appendix A regarding specific definitions)

The total scores attained by each of the subjects were ranked according to Guttman's (1947) scalogram analysis, cutting points were established in such a way as to minimize error as outlined by Guttman and the number of errors (e) computed and summed. Coefficients of reproducibility were computed for each component. Results indicate that the proposed sequence of terminal objectives in each area for the CRA-MD does constitute a scale. This supports the premise that the terminal objectives are arranged in an ordinal sequence.

Research Question II

The second research question pertained to the scalability of the enabling objectives within the first seven motor areas of the CRA-MD. Question II is as follows:

> Given a heterogeneous group of children between the ages of two and six years, the proposed sequence of enabling objectives will be assessed for scalability within each

motor area. The objectives will be considered scalable if 90% coefficient of reproducibility or better is established in each area.

Tables VII through XIII show the skills by subject matrices for each motor area. The total scores attained by each of the subjects were ranked, and cutting points established as outlined by Guttman (1947). The number of errors was ascertained for each objective within the sequence. The products were summed and coefficients of reproducibility computed. The results are listed in Table XIV and show that the 90% reproducibility level was exceeded in each case. These results indicate that scalability has been achieved in all motor areas and that the proposed sequence of terminal and enabling objectives for the CRA-MD possesses ordinality.

By consulting the skills by subject matrices (outlined in Tables VII through XIII), it can be seen that at least two-thirds of the heterogeneous sample demonstrated mastery on the terminal and enabling objectives contained within the first seven items of the CRA-MD. This ceiling effect may influence the degree of scalability attained: Guttman (1947, p. 260) states that "reproducibility can be artificially high simply because one category in each item has a very high frequency" therefore scalogram analysis was performed on each matrix so as to include all performance variations below attainment of a maximum score. Eight to ten subjects fell within this category and from these scores coefficients of reproducibility were prepared, and results of this analysis are outlined in Table XV. Scalogram analysis again indicates that scalability has been achieved as all coefficients of reproducibility exceed the 90% level required.

TABLE VII

SKILLS BY SUBJECT MATRIX FOR TERMINAL & ENABLING OBJECTIVES: CONTROLLED EYE MOVEMENTS

	1A					1					2					3				
Score	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
19	x						x				x					x				
19	x						x				x					x				
19	x						x				x					x				
19	x						x				x					x				
19	x						x				x					x				
18	x						x				x						x			
18	x							x			x					x				
17	x							x			x						x			
16	x							x				x					x			
16		x						x			x						x			
15		x					x				x								x	
	24	0	2	0	0	15	7	4	0	0	25	1	0	0	0	21	4	0	1	0
p & q	.923	.077				.576	.269	.153			.96	.038				.807	.153	.038		
e	2					4					1					2				(e=9)

(20)(26) = 520

9/520 = .0173076

1 - .0173076 = .9826924

Coeff. Rep. = .982

TABLE VIII

SKILLS BY SUBJECT MATRIX FOR TERMINAL & ENABLING OBJECTIVES: HEAD CONTROL PRONE

	2A	1	2B	1	2	2C	1	2
Score	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1	5 4 3 2 1
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
40	x	x	x	x	x	x	x	x
39	x	x	x	x	x	x	x	x
39	x	x	x	x	x	x	x	x
34	x	x	x	x	x	x	x	x
29	x	x	x	x	x	x	x	x
	24 2 0 0 0	23 3 0 0 0	24 2 0 0 0	24 1 1 0 0	25 1 0 0 0	24 2 0 0 0	24 2 0 0 0	24 1 1 0 0
p & q	.923 .077	.885 .115	.923 .077	.923 .038 .038	.923 .077	.923 .077	.923 .077	.923 .038 .038
e	2	0	0	1	0	0	0	1 (e=4)

Postural Maintenance
(10)(26) = 260
2/260 = .0076923
1 - .0076923 = .9923077
Coeff. Rep. = .992

Postural Assumption
(15)(26) = 390
1/390 = .0025641
1 - .0025641 = .9974359
Coeff. Rep. = .997

Locomotion/Movement
(15)(26) = 390
1/390 = .0025641
1 - .0025641 = .9974359
Coeff. Rep. = .997

TABLE IX

SKILLS BY SUBJECT MATRIX FOR TERMINAL & ENABLING OBJECTIVES: HEAD CONTROL SUPINE

	3A					3B					1					3C					1				
Score	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
25	x					x					x					x					x				
24		x				x					x					x					x				
24		x				x					x					x					x				
24		x				x					x					x					x				
24	x					x					x						x				x				
24	x					x					x						x				x				
23		x				x					x						x				x				
23			x			x					x					x					x				
22			x				x				x					x						x			
21			x			x						x					x					x			
20			x					x			x					x					x				
18			x				x				x							x				x			
15			x				x				x						x					x			
	16	4	6	0	0	22	3	1	0	0	23	3	0	0	0	20	5	1	0	0	23	3	0	0	0
p & q	.615	.153	.230			.846	.115	.038			.885	.115				.769	.192	.308			.885	.115			
e		6				1	1				0					3	1				1				(e=13)

Postural Maintenance (one objective only)

Postural Assumption
(10)(26) = 260
2/260 = .0076923
1 - .0076923 = .9923077
Coeff. Rep. = .992

Locomotion/Movement
(10)(26) = 260
5/260 = .0192307
1 - .0192307 = .9807693
Coeff. Rep. = .98

TABLE X

SKILLS BY SUBJECT MATRIX FOR TERMINAL & ENABLING OBJECTIVES: ROLLING

	4A					1					2					4B				
Score	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
20	x					x					x					x				
19	x					x						x				x				
18	x						x				x					x				
17			x			x					x					x				
16	x						x							x		x				
4				x				x					x							x
4				x				x					x							x
	23	0	0	1	2	22	1	1	0	2	22	1	0	1	2	24	0	0	0	2
p & q	.885		.038	.077		.846	.038	.038	.077		.846	.038	.038	.077		.923				.077
e				2		1	1						1		1					2 (e=8)

Postural Maintenance
(15)(26) = 390
6/390 = .0153846
1 - .0153846 = .9846154
Coeff. Rep. = .984

Postural Assumption (one objective only)

TABLE XI

SKILLS BY SUBJECT MATRIX FOR TERMINAL & ENABLING OBJECTIVES: SITTING

	5A	1	2	3	4	5	5B1	1	2	3	4	5B11	1	5C
Score	5 4 3*	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3	5 4 3
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
70	x	x	x	x	x	x	x	x	x	x	x	x	x	x
69	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	26 0 0	26 0 0	26 0 0	26 0 0	26 0 0	26 0 0	26 0 0	26 0 0	25 1 0	26 0 0	26 0 0	26 0 0	26 0 0	26 0 0

p & q .96 .038

e 1 (e=1)

Postural Maintenance
(30)(26) = 780
0/780 = 0
Coeff. Rep. = 1.0

Postural Assumption

[B1]
(25)(26) = 650
1/650 = .0015384
1 - .0015384 = .9984616
Coeff. Rep. = .998

[B11]
(10)(26) = 260
0/260 = 0
Coeff. Rep. = 1.0

Locomotion /Movement (one objective only)

*no subject attained less than level 3.

TABLE XII

SKILLS BY SUBJECT MATRIX FOR TERMINAL & ENABLING OBJECTIVES: CRAWLING

	6A					1					2					6B1					1					2					6B11					6C					1					2				
Score	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
50	x					x					x					x					x					x					x					x					x					x				
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
50	x					x					x					x					x					x					x					x					x									
49	x					x					x					x					x					x					x					x					x									
47	x					x						x				x					x					x					x					x					x					x				
46	x					x					x					x						x				x					x					x					x					x				
45		x					x					x					x					x					x					x					x					x					x				
45	x					x					x					x					x					x					x					x					x						x			
44		x				x					x					x					x					x					x					x					x					x				
44	x					x					x					x					x					x					x					x					x						x			
43	x					x					x					x					x					x					x					x					x					x				
41		x					x					x					x					x					x					x					x					x					x				
34		x					x					x					x					x					x					x					x					x					x				
	22	1	1	2	0	23	1	1	1	0	23	2	1	0	0	23	2	1	0	0	24	0	1	0	1	23	2	1	0	0	22	4	0	0	0	23	2	1	0	0	21	3	2	0	0	19	2	3	2	0
p & q	.846 .038 .038 .977					.885 .038 .038 .038					.885 .077 .038					.885 .077 .038					.846 .038 .038					.885 .077 .038					.846 .153					.885 .077 .038					.807 .115 .077					.730 .077 .115 .077				
e	1	1				1	1				2					1	1									1	1	1			3					1	1	1			1	1	2			3	2	(e=26)		

Postural Maintenance
(15)(26) = 390
6/390 = .0153846
1 - .0153846 = .9846154
Coeff. Rep. = .984

Postural Assumption
(15)(26) = 390
5/390 = .0128205
1 - .0128205 = .9871795
Coeff. Rep. = .987

Locomotion/Movement
(20)(26) = 520
12/520 = .0230769
1 - .0230769 = .9769231
Coeff. Rep. = .976

TABLE XIII

SKILLS BY SUBJECT MATRIX FOR TERMINAL & ENABLING OBJECTIVES: WALKING

	7A			1			2			3			4			5			6			7B1			1			2			3			4			7B11			1			7C			1			2			3			4		
Score	5	4	3*	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3	5	4	3
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
95	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
94		x		x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
93			x	x			x			x			x			x			x			x			x			x			x			x			x			x			x			x			x		
	24	1	1	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0	26	0	0

p & q

.923

.038

.038

e 1 (e=1)

Postural Maintenance
(35)(26) = 910
1/910 = .0010989
1 - .0010989 = .9989011
Coeff. Rep. = .998

Postural Assumption
[B1]
(25)(26) = 650
1/650 = 0
Coeff. Rep. = 1.0

[B11]
(25)(26) = 650
0/260 = 0
Coeff. Rep. = 1.0

Locomotion/Movement
(25)(26) = 650
0/650 = 0
Coeff. Rep. = 1.0

*no subject attained less than level 3.

TABLE XIV

SUMMARY OF COEFFICIENTS OF REPRODUCIBILITY
OBTAINED FROM TABLES VII - XIII

Motor Area	Coefficient of Reproducibility		
	Postural Maintenance	Postural Assumption	Locomotion /Movement
Controlled Eye Movements	.982	*	*
Head Control Prone	.992	.997	.997
Head Control Supine	**	.992	.98
Rolling	.984	**	*
Sitting	1.0	.998	**
Crawling	.984	.987	.976
Walking	.998	1.0	1.0

*component area not applicable to motor area.

**one objective only in component area, coefficient not computed.

TABLE XV

RESULTS OF SCALOGRAM ANALYSIS SHOWING THE COEFFICIENTS OF REPRODUCIBILITY PERTAINING TO RESEARCH QUESTION II

A. TERMINAL OBJECTIVES

Component Area	Coefficient of Reproducibility
Postural Maintenance	.957
Postural Assumption	.98
Locomotion/Movement	.975

B. TERMINAL & ENABLING OBJECTIVES

Motor Area	Postural Maintenance	Postural Assumption	Locomotion /Movement
Controlled Eye Movements	.957	*	*
Head Control Prone	.975	.991	.991
†Head Control Supine	**	.98	.95
Rolling	.958	**	*
Sitting	1.0	.998	**
†Crawling	.96	.96	.96
Walking	.998	1.0	1.0

†calculated on 10 lowest scores.

*component areas not applicable to motor area.

**one objective only in component area, coefficient not computed.

Research Question III

> Given a heterogeneous group of children between the ages of two and six years, the degree of association between scores attained on the CRA-MD and anthropometric measures, height and weight, will be ascertained. An association or correlation will be indicated if the results of the Spearman rank correlation coefficient is significant at P = .05 level.

This research question was tested using Spearman's rank correlation coefficient: r_s. By correlating height and weight percentile ranks for age with performance proficiency ratings obtained on the terminal objectives within the three component areas, postural maintenance, postural assumption and locomotion, six rank order correlation coefficients resulted. A correlation coefficient was considered significant if it surpassed the critical value of .388 (P = .05, df = 26).

Spearman's rank correlation coefficient: r_s was employed indicating a significant correlation between height and the postural maintenance component of the CRA-MD (level of significance for a two tailed test, P = .05, df = 26, critical value .388, r_s = .505). As the attained value exceeded the critical value it has been demonstrated that the anthropometric measures are related to performance on items pertaining to the maintenance of posture on the CRA-MD by subjects in this sample.

Employing the same method of analysis a significant correlation between the assumption of posture component and height was found (level of significance for a two tailed test, P = .05, df. = 26, critical value = .388, r_s = .488). Height is thus related to performance on items pertaining to postural assumption.

The degree of association between height and performance on the locomotion/movement component was not found to be significant when

employing Spearman's r_s (level of significance for a two tailed test, P = .05, df = 26, critical value .388, r_s = .192). As the attained value does not exceed the critical value it cannot be stated that height was related to performance of subjects within this sample on items pertaining to locomotion.

The same method of analysis was employed to ascertain the degree of association between weight and performance of the three major component areas of the CRA-MD. None of these Spearman rank correlation coefficients: r_s were found to be significant.

Results showed the correlation coefficient between weight and postural maintenance failed to attain significance (level of significance for a two tailed test, P = .05, df = 26, critical value .388, r_s = .263). A similar result was attained when weight and postural assumption were correlated (level of significance for a two tailed test, P = .05, df = 26, critical value .388, r_s = .262). Results of the correlation coefficient between weight and locomotion were not significant at the .05 level (level of significance for a two tailed test, P = .05, df = 26, critical value .388, r_s = .300).

As none of the attained values exceeded the critical value it was not demonstrated that weight was related to performance on the terminal objectives for the three component areas of the CRA-MD by subjects in this sample.

Summary

Results indicate that the proposed sequence of objectives within the first seven items of the CRA-MD are scalable and overall, ordinally sequenced. It has been demonstrated that this portion of the

CRA-MD is scalable, as it has been shown to exceed the required 90% reproducibility level in all areas on which scalogram analysis was performed. In an effort to account for a ceiling effect due to a high frequency of mastery level performance on the part of two-thirds of the sample, scalogram analysis was applied to the lowest scores on the skills by subject matrices. Results included in this analysis were from those subjects which attained less than mastery level on each item. Again, 90% reproducibility was exceeded in each area.

The degree of association between the anthropometric measure height was found to be significantly correlated with the performance on items pertaining to postural maintenance and postural assumption. However, performance on items pertaining to the locomotion/movement component was not found to be significantly correlated with height of subjects within this heterogeneous group. None of the three component areas were found to be significantly correlated with weight for this group.

CHAPTER VI

DISCUSSION

The purpose of this study was to establish the degree of scalability within the first seven motor areas of the Criterion-Referenced Assessment Guide - Motor Development (CRA-MD, Kysela et al., 1976) when validated with a heterogeneous sample. It was proposed that the sequence of objectives would be attained in the order outlined regardless of the type or severity of the handicapping conditions included within the sample, thus each subject would demonstrate his individual level of attainment without violating the proposed sequence of objectives.

Each of the areas pertaining to the research questions will be discussed in the following sections, observations regarding the performance of the first seven motor areas of the CRA-MD will be included, and recommendations for adapting various aspects of the instrument on the basis of this data. A discussion of the implications of this study and an outline of future research needs in this area will follow.

Research Question I

The results of the scalogram analysis undertaken on the terminal objectives within the three component areas across the seven steps in the sequence revealed coefficients of reproducibility well above the required 90% level. This pertains to both the total sample and the sub-group of lowest scores analyzed separately.

Postural maintenance: Within the postural maintenance component it was observed that although all of the subjects included in

the heterogeneous sample could perform the necessary motor skills, they had difficulty holding positions for the time period specified. This was particularly evident in the motor area requiring head control while in the supine position. No subject could hold his head five centimetres off the floor for the required 15 seconds, but all succeeded in maintaining this position for five seconds.

It is suggested that although maintenance of this posture is necessary for head control it is only momentarily used during the pursuit of everyday activity once independent locomotion has been established. Similar difficulties were not encountered with head control in the prone position. This posture is frequently required in everyday activity for all age groups, as it is necessary for maintaining eye contact with objects manipulated by the hands, such as block play, drawing, and printing. Užgiris and Hunt (1975) outlined another point of view which may be considered here. They state that "once an infant has achieved higher levels of organization in his actions elicited by one situation, it becomes very difficult to get those situations to elicit the earlier, cruder patterns of behavior" (p. 126). In the assessment of head control in the supine position, it is possible that the successive steps involve a reorganization of behavior rather than "simple accretions of elements" (p. 125) in such a way that the earlier patterns have been incorporated into more complex levels of behavior and will not be exhibited to the same degree by the older child, the two to six year old, as observed in the infant. Užgiris and Hunt (1975) found that lower levels of behavior could not be elicited except under unusual circumstances.

A similar situation occurred with the assessment of head

control supine (see Appendix A, Item 3a) where it became necessary to hide the toy behind the subject's foot in order to prompt head raising and turning in the supine position. Offering "a toy within view," or a toy held 20 - 30 cm. in front of the subject's face" as outlined in the assessment guide was not sufficient. However, when using the device as an assessment guide for developmentally disabled children, it is unlikely that this problem would be encountered.

In order for attention to be focused for the required length of time in the sequence assessing controlled eye movements, objects or toys used must be of interest to the subject -- the colored peg (required in Item 1a) was not adequate for the two to six year old. Small animals which were as realistic as possible appeared to hold the greatest interest for this group.

Maintenance of attention over the three trials successively provided some difficulty, as the tasks in this component area were not generally interesting to the subjects. They entail the maintenance of static positions which appear to be the very opposite of the type of activity engaged in by choice by this age group. With the exception of the motor area "head control supine", every subject was well able to perform the motor skills required in this section. The difficulty arose in getting them to perform the skill for assessment purposes. The possibility of observation of the subject during free play should be considered in addition to the assessment, as it was observed that subjects performed the majority of the motor skills assessed using the CRA-MD spontaneously during play.

The skills by subject matrix for terminal objectives (Table IV) shows that the greatest variation in performance occurred in the motor

areas of head control supine, rolling and crawling. Within the head control supine sequence, two hearing-impaired subjects and 18 unimpaired subjects attained maximum performance proficiency ratings. The remainder of the sample (including three hearing-impaired, two Down's subjects and one unimpaired subject) attained level 3. Within the sequence of objectives pertaining to rolling, the two Down's subjects attained level 1 performance ratings, as they were unable to complete the task without being put through the required objective. One unimpaired subject attained a level 2 performance rating, and, like the Down's subjects, she did not appear to comprehend the meaning of the command "roll", although each was physically able to complete the task. This may indicate that with younger children especially, this objective should include the examiner modeling the task, thus avoiding sole reliance on the one-word command.

It is of interest that all subjects could maintain the required sitting posture without difficulty and it was apparent in each program that this skill was well established as part of the regular program routine.

The variation noted in performance levels in the remaining areas (controlled eye movements, head control prone, crawling and walking) consistently demonstrated that the Down's subjects required a level 3 prompt (demonstration) or below (physical prompt) to demonstrate the required motor skill. It was found that the prompting level dropped not as a function of poorly developed motor skills, but as a function of the amount of attention given by the subject to the task.

Recommendations:

1. Controlled Eye Movements: Small, lifelike toy animals

should replace the colored peg required in objective 1a, at least three should be available.

2. Head Control Supine: Five seconds should be the required time for maintaining the head position.

3. Rolling: Inclusion of examiner modeling the task within the terminal objective.

4. Inclusion of at least one and possibly several observation periods during a child's free play for observation of the spontaneous use of motor skills.

Postural Assumption: Mastery level was attained on five of the eight motor areas by all subjects in the sample. The three areas to which this proficiency level does not pertain are head control supine, rolling, and assuming the crawling position.

Within the head control supine sequence, the necessity to raise the head was not built into the objective. It was found that tapping the sole of the foot, or the floor in that area, with a small toy previously used and using the command "where is the _____?" elicited the required response (see Appendix A, objective B1). However, the subjects invariably supported themselves on their elbows to maintain the posture. On this item, one hearing-impaired child required level 3 prompting, all other subjects attaining mastery. It would appear that having experienced what was required during assessment of the postural maintenance component, the requirements of postural assumption were easily completed by the majority of subjects.

Item 2B1 (raises head) required the use of an auditory stimulus (a sound made 15 cm. above the child's head) which was not appropriate for the hearing-impaired subjects. This item was therefore

adjusted to read as follows for all subjects: Raises head: In the prone position (not supported on elbows) child will raise his head 8 cm. off floor within 5 seconds of being told to "look" and offered a toy within view.

Within the rolling sequence, however, the Down's subjects both required level 1 prompting. They appeared to have had little experience with the task, or lacked familiarity with the command "roll". Hearing-impaired subjects were able to attain mastery after previous experience with the command.

Assumption of four-point kneeling from sitting (see Appendix A, Item Bii) initially required a level 3 prompt, i.e., demonstration. The command "crawl" as outlined in the guide prompted both assumption and locomotion in that position. Generally this component area was more interesting to the subjects as it entailed some movement.

It was found that all items requiring primarily one position should be assessed at the one time. That is, if movement on the floor was entailed for a series of items such as rolling, crawling, sitting, etc., then all those items -- regardless of the motor area involved -- should be assessed together. For example, Items 1 through 4 require work on the floor: Item 5Bi (comes to sit from lying) and enabling objectives also require the floor and should next be included. Item 5C (lies down from sitting) should follow, and Item 6 should then follow in its entirety.

The sitting position is next required, and Item 5A (sits with back unsupported on floor and stool) and enabling objectives should be completed. Item 5Bii (sits on stool from stand) can be more easily assessed when assessing Item 7Bi (stands up from chair unassisted) if

three successive trials are using the command "sit down" and the task of assuming the sitting position is required between each. It should be remembered that these adjustments to the order of items were required for a sample of two to six year old subjects who had no physical handicaps. It was found that the assessment could be performed more quickly and the subjects appeared to be less fatigued when items were grouped in this manner. Terminal objectives were never removed from their corresponding sequence of enabling objectives: if an item was moved, all corresponding objectives were included. It was not the intention to violate the sequence but to make use of the positions as they would normally present themselves with as little energy cost as possible.

Recommendations:

1. That items be included in the assessment in the order that is most convenient for the subject, providing the sequence of terminal and corresponding enabling objectives is not violated.

2. Item 3B should read "(1) Lifts head: Child will lift his head momentarily at least 2 cm. off the floor within 5 seconds of being asked 'where is the _____?', which is tapped on the sole of his foot or on the floor directly below it."

Locomotion/Movement: Mastery was attained by all subjects with the exception of two motor areas, head control supine and crawling. In both of these areas the lowest prompting level required was level 3. Here, one child with Down's syndrome attained a level 3 proficiency rating on head control supine and a non-impaired subject also gained a level 3 proficiency rating. Again, it would appear that attention to the task was the area of difficulty, and not the performance of the motor skill per se. With the movement required in the assessment of

this component area, the subjects' degree of interest in the task was generally high.

The high degree of scalability in this component area is possibly influenced by the pretest of entry level skills, which required that each subject demonstrate mastery performance of Item 7C (walks in a co-ordinated fashion) in order for them to participate in the validation study. This therefore assured a high degree of uniformity on one item in this component, thus increasing the probability for attaining a high percentage of reproducibility.

The command "walk" on Item 7C did not elicit a natural gait pattern from subjects who otherwise demonstrated in spontaneous behavior that their gait pattern was quite adequate. The usual response was an inhibited, stiff walk not unlike that of a toy soldier. In an effort to eliminate this response, the command was changed to "walk to the _____ and get the _____"; this produced a half-trot out and a run back with the object. In order to elicit a normal gait pattern, the command had to altered to "walk with me to the _____". It was found that the most natural place in the assessment to administer this item was en route to the room being used. This way there was a purpose to the walking task without it becoming a performance for the benefit of the examiner. These difficulties were not encountered with other items within this component when the subject was asked to grasp an object or the examiner's finger and walk a specified distance.

Recommendation: Independent walking should be assessed in a natural, purposeful context to promote the gait pattern usually used by the subject.

In summary, the results of the scalogram analysis indicate

that the sequence of terminal objectives within the three major component areas is ordinal. Several modifications have been recommended as a result of this validation study.

Research Question II

The results of the scalogram analysis undertaken on the terminal and enabling objectives within the three component areas revealed coefficients of reproducibility well above the required 90% level. This finding pertains to both the total sample and the subgroups of lowest scores analyzed separately.

Postural Maintenance: Within the postural maintenance component no coefficient fell below .984 for the total sample and .957 for the subgroup of lowest scores.

Within the sequence of objectives pertaining to controlled eye movements, subject performance on eye movements on back (see Appendix A, Item 1) showed the greatest variability. Both Down's subjects, one hearing-impaired subject, and one unimpaired subject attained level 3 proficiency ratings. Here, attention to the task at hand appeared to affect performance. The ability to visually track an object through a 180° arc was demonstrated but interest over three successive trials was difficult to sustain for these individuals. The remainder of the sample did not appear to have any difficulty with the number of successive trials. It is possible that the younger children have greater difficulty with this task; both the hearing-impaired and unimpaired subjects were amongst the youngest subjects in the sample.

All subjects attained mastery of the terminal and enabling objectives within the head control prone sequence. The situation with

the head control supine sequence objectives was fully discussed under Research Question I.

Within the rolling sequence it was noted that younger children within the sample (i.e., those under four years of age) experienced difficulty in differentiating between the terms "back" and "front" when attempting to follow the commands "roll to back" and "roll to front" (see Appendix A, Items 4A1 and 4A2). Level 2 and 3 prompts were required on the first, but not on subsequent trials.

Mastery was attained through all the objectives within sitting; however, within the sequence of objectives pertaining to crawling, level 2 and 3 prompting was required by both Down's subjects and one hearing-impaired subject. The remainder of the sample attained mastery of this objective. In walking, mastery was attained by all subjects, with the exception of one Down's syndrome subject, who required a level 3 prompt to maintain the standing posture.

In the series of objectives pertaining to walking (see Appendix A, Item 7A) the hand-held plumb line proved to be a quickly and easily applied method of assessing maintenance of the correct standing posture. Prompting within the postural maintenance component of the walking objectives was accomplished without difficulty.

Although the situation did not arise during this investigation, it would appear that prompting with the young hearing-impaired population would pose difficulties due to the limited vocabulary usually attained by these children before five years of age.

Postural Assumption: Within the postural assumption component no coefficient fell below .987 for the total sample and .96 for the subgroup of lowest scores.

Within the sequence pertaining to head control prone, one Down's subject attained level 3 on the item "raises head" (see Appendix A, Item 2Bi), while all other subjects attained mastery throughout. The provision of a series of objects of interest to the child appeared to influence positively the level of performance attained.

Head control supine and rolling sequences were fully discussed under Research Question I. Mastery was attained by all subjects on the sequence of objectives pertaining to sitting and walking, however, some variation was noted in crawling. One unimpaired child attained level 1 on the item "pushes up with arms straight from prone" (see Appendix A, Item 6Bi1); again this subject was one of the youngest in the sample. Level 3 was attained by an unimpaired subject of the same age on the item "pushes to heel sit" (see Appendix A, Item 6Bi2).

Locomotion/Movement: Within the locomotion component no coefficient fell below .98 for the total sample and .95 for the sub-group of lowest scores.

Within the sequence pertaining to head control prone, one Down's subject attained level 3 on "raises head" (see Appendix A, Item 2C2), the remainder of the sample attaining mastery. The degree of attention to the task again appeared to relate to performance levels demonstrated here. Head control supine sequences were fully discussed under Research Question I. Mastery was attained by all subjects in sequences pertaining to sitting and walking; however, some variability was noted in crawling sequences within this component. Three subjects attained level 3 and two attained level 2, one Down's subject, two hearing-impaired and two non-impaired subjects attaining these levels. Younger children did not consistently perform at these lower levels:

ages of subjects with lower performance levels varied and did not follow any consistent pattern.

Prompting within the sequence of objectives pertaining to walking for the locomotion component area proved to be very difficult. The major problem appeared to be the number of elements requiring evaluation at the same time. Six factors or elements pertaining to maintenance of posture (head up, back straight, hips extended so hip joint is straight above ankle joint, knees not hyperextended, feet externally rotated 10° to 40°, feet hip-distance apart) require monitoring at the same time as the three postural factors pertaining to Item 7C, walks in a co-ordinated fashion (without loss of balance, using a heel-toe gait, and having reciprocal arm-swing opposite to heel-strike foot). For assessment purposes it would appear necessary to increase the number of times the subject walks the 6 m. distance on each trial, thus giving the examiner more time to monitor each element. Prompting a particular element frequently appeared to throw other postural components out, which were previously adequately demonstrated. The situation is compounded with the young deaf child's communication difficulties. No other difficulties were encountered with the total communication method of instruction for deaf subjects when using other areas of the assessment guide.

In summary, some difficulty experienced by younger children within the sample on the rolling sequence of objectives may have been due to difficulty differentiating the front from the back of the body, a situation which is not uncommon for three to four year olds.

Prompting levels are difficult to utilize within the walking sequence, the necessity to monitor nine postural elements simultaneously

over each trial requiring additional instructions for the examiner within the assessment guide. Examples of prompting should be included for clarification.

Research Question III

Anthropometric measures were found to relate to scores attained on the CRA-MD in two component areas, postural maintenance and postural assumption, but not to locomotion. The possibility that height and weight of subjects could be associated with the ability to maintain a certain position as well as assume that position is plausible. Whether this works against the taller and heavier subjects is not known; however, it was observed that one unimpaired subject who was in the 97th percentile rank for weight had difficulty maintaining an unsupported sitting position on the floor without a rounded back. No difficulties were noted in the performance of subjects on the other end of the scale within the 3rd percentile rank.

The possibility that once balanced and mobile the height and weight of a subject do not influence their locomotor abilities should be considered. The lack of association between these anthropometric variables and scores obtained on the terminal objectives of the CRA-MD may also be due to a third factor or set of factors which remains unknown.

Implications

The implications of the study just described generally lie in the areas of assessment of the motor skills of the exceptional child specifically in the area of designing and implementing remedial programs.

The Criterion-Referenced Assessment Guide -- Motor Development is in general a quickly administered assessment of motor skill development with minimal equipment requirements. Test instructions in the form of objectives are easily followed. One of the major difficulties with the test in it's present stage of development is the necessity for verbal commands to precede each motor act, for although the child may demonstrate that he can perform a motor skill quite accurately spontaneously, the assessment requires that the performance of a task be rated following a specific command, modeling by the examiner, or a nonverbal stimulus. The examiner is thus forced to use a level of prompting which serves to focus the child's attention to the task at hand, and does not refer to his level of motor ability.

The use of three successive trials provides a mechanism for demonstrating the required task to those children who rely to a large extent on sight to obtain information, the severely and profoundly deaf, without penalizing them in terms of the final result obtained. This sequence is extremely useful with this group of exceptional children, as test batteries designed for hearing populations frequently penalize the deaf child because of his communication deficit, and not due to his lack of skill.

Test results are easily converted into remedial programs using the "test-teach model" (Kysela et al., 1976) which will benefit exceptional children and instructors. In areas where resource personnel are few and budgets small, an instructor can quickly master the assessment skills necessary to make use of the guide and investment of both equipment and time is minimal.

Individual programs are devised for each motor area in which

mastery has not been attained. Each of these elements should be of great assistance to the teacher or therapist working with a group of handicapped children who is unclear of exactly where and how to start to implement an appropriate program. With the emphasis on early intervention, it is anticipated that the assessment guide will provide the necessary link between assessment and remedial programming which is so urgently needed.

Future Research

An assessment of those subjects who did not demonstrate mastery of Item 7C (walks in a co-ordinated fashion) may have provided additional information regarding the ordinality of the proposed sequence of objectives by indicating the sequence of attainment by those who were performing at lower levels.

The next logical step after the study presented in this thesis would be to validate the remaining items on the Criterion-Referenced Assessment Guide -- Motor Development. A study utilizing the entire assessment with at least 50 subjects should then be undertaken. Replication of the high percent reproducibility attained on the first seven items of the guide would provide necessary data on the reliability of the instrument.

Studies involving the use of the instrument with other exceptional groups may demonstrate it's use within such areas as physical disability. The possibility that this method of assessment and remediation be tried with physically disabled adults who are forced to relearn basic self-help skills following illness or injury should also be investigated.

Summary

The present study sought to evaluate the ordinality of the Criterion-Referenced Assessment Guide -- Motor Development using a heterogeneous sample. The sequence of objectives contained in the first seven motor areas of this instrument was included in the study. In addition, the relationship between height and weight of the subjects and their performance on the CRA-MD was investigated.

The literature regarding motor development and milestone attainment for hearing-impaired and Down's syndrome populations suggested that delays in attainment of milestones as well as adquate equilibrium reactions (balance skills) were not uncommon within both groups. Numerous causes have been hypothesized but these have served primarily as an obstacle to further research and remedial programming instead of an assistance to further development in these areas. It was proposed that a criterion-referenced assessment approach would bridge the gap between assessment and implementation of remedial programming, as this type of assessment relates directly to instructional levels. Normative assessment methods had provided longitudinal data on the motor development of unimpaired populations; however, comparison with the attainments of the normal population appears to serve little purpose in the assessment of the exceptional child when the object of that assessment is the construction of an individual remedial program. The criterion-referenced assessment approach was therefore selected. Of the three criterion-referenced assessments available in the motor area, the Criterion-Referenced Assessment Guide -- Motor Development devised by Kysela et al. (1976) was the most comprehensive, and was therefore selected for evaluation purposes. The first seven motor areas were included in

the study.

Fifty subjects were randomly selected from a heterogeneous pool of 75 subjects available. Subjects were attending one of three day programs within the city which serve the hearing-impaired, moderately handicapped, and unimpaired populations. Following a pretest with the highest level objective within the seven terminal objectives, 26 subjects remained in the study. The first seven motor areas of the CRA-MD were then assessed with these subjects. Anthropometric data, height and weight, were also recorded for these subjects. The results indicated that the sequence of objectives within the criterion-referenced assessment of motor skills was scalable when tested with this heterogeneous sample. A relationship was found to exist between the anthropometric measure height and the postural maintenance and postural assumption components of the assessment guide, but not with the locomotion/movement component area. No significant relationship between weight and those variables was found.

The CRA-MD proved to be a quickly administered, and comparatively easy assessment to perform. It required minimal equipment and provided information which would relate directly to remedial programs where necessary. Several modifications to the instrument have been recommended in order to clarify the command contained within an objective or prompt the required response more efficiently.

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APPENDIX A

THE UNIVERSITY OF ALBERTA, EDMONTON, CANADA T6G 0Y1
CENTRE FOR THE STUDY OF MENTAL RETARDATION

Criterion Referenced Assessment Guide

in Cognition
Motor Development
Language
Self-Help Skills

First Draft, NOT for Publication
Please Contact G.M. Kysela, Coordinator
Early Education Project

AN INTERDISCIPLINARY RESEARCH CENTRE, CO-SPONSORED BY
THE UNIVERSITY OF ALBERTA AND THE CANADIAN ASSOCIATION FOR THE MENTALLY RETARDED

CRITERION-REFERENCED ASSESSMENT GUIDE

MOTOR DEVELOPMENT

1. Controlled Eye Movements

	1	2	3

A. Looks at object in hands (P15A)*

(1) eye movements on back (P5)

(2) looks and holds (P7A)

(3) looks at hands (P14)

2. Head Control Prone

	1	2	3

A. Holds head and chest up 15 seconds prone on elbows (P13)

(1) holds head up 5 seconds (P6)

B. Lifts head - prone on elbows

(1) raises head within 5 seconds (P2)

(2) raises head within 5 seconds prone on elbows (P8)

C. Turns head and reaches for toy prone on elbows

(1) head turning (P3)

(2) raises head (P8)

3. Head Control Supine

	1	2	3

A. Holds head up 15 seconds

*Adapted from similar item in Portage Program (Martin et al. 1975)

3. Head Control Supine (continued)

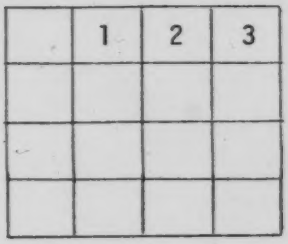
B. Lifts head within 5 seconds

(1) lifts head momentarily within 5 seconds (P11A)

C. Turns head

(1) moves head side to side (P4)

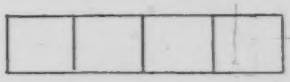
4. Rolling



A. Rolls back to stomach

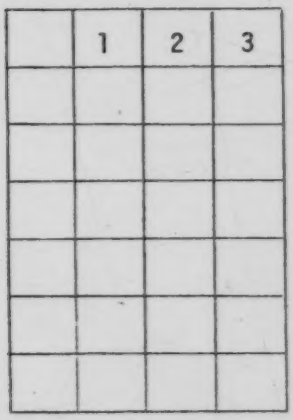
(1) rolls side to stomach

(2) rolls side to back



B. Rolls stomach to back (P21)

5. Sitting



A. Sits with back unsupported on floor and stool (P29)

(1) head erect

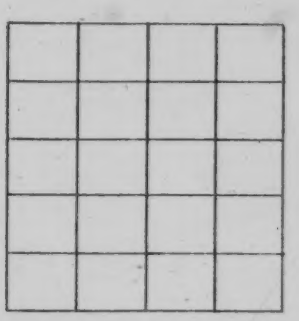
(2) sit with maximum body support (P9)

(3) holds head steady when carried (P10)

(4) sits with minimum support (P19)

(5) sits self-supported on floor (P24)

5. Sitting (continued)



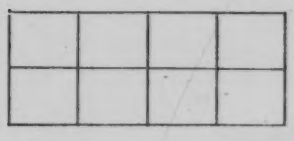
Bi. Comes to sit from lying (P27)

(1) rights self (P6A)

(2) turns head freely in sitting (P12)

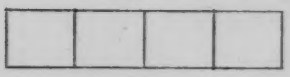
(3) holds head erect when pulled to sitting (P15)

(4) comes to sit with aid (P22)



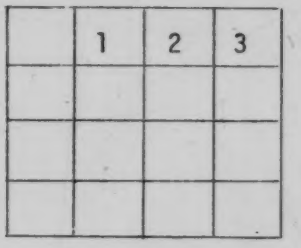
Bii. Sits on stool from stand (P53)

(1) lowers self to sitting (P38)



C. Lies down from sitting (P26)

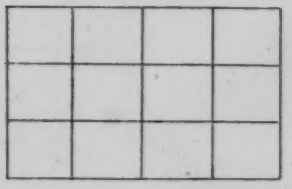
6. Crawling



A. Balances on hands and knees

(1) prone with arms straight

(2) heel sit with arms straight



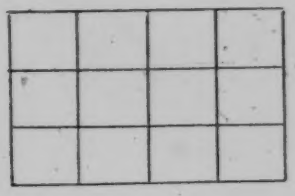
Bi. Raises to hands and knees from prone

(1) pushes up with arms straight from prone

(2) pushes to heel sit

Bii. Turns from sit to hands and knees (P32)

6. Crawling (continued)

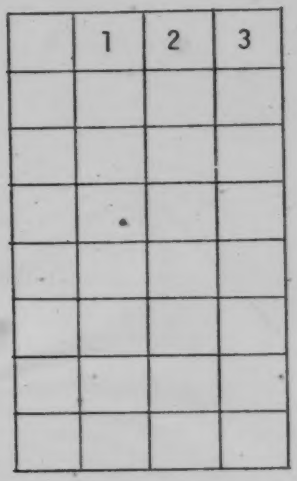


C. Crawls (P30)

(1) creeps on abdomen (P25)

(2) rocks on hands and knees (P24A)

7. Walking

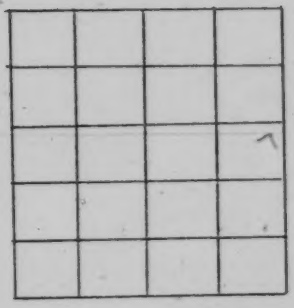


A. Stands with correct posture

(1) bears weight on feet (P23)

(2) stands self-supported when holding stable object with 2 hands (P35)
(3) stands self-supported when holding stable object with 1 hand (P35)
(4) stands self-supported when holding flexible hose with 1 hand
(5) stands momentarily unsupported

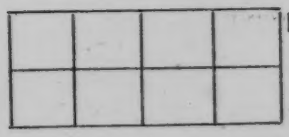
(6) stands unsupported (P41)



Bi. Stands up from chair unassisted

(1) puts feet flat on floor

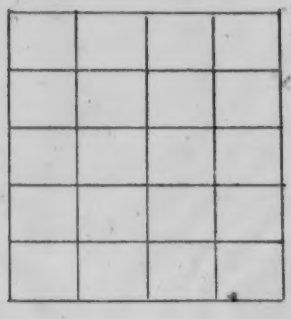
(2) pulls self to standing when holding stable object with 2 hands (P35)
(3) pulls self to standing when holding stable object with 1 hand
(4) pulls self to standing when holding flexible hose with 1 hand



Bii. Stands up from supine lying on floor

(1) stands from sitting on floor by pulling on furniture

7. Walking (continued)



C. Walks in co-ordinated fashion

(1) walks when holding stable object with 2 hands (P40)
(2) walks when holding examiner's finger with 1 hand (P55)
(3) walks when holding flexible hose with 1 hand
(4) walks unsupported

1. Controlled Eye Movements

A. In the supine position the child will focus his eyes on a colored peg (1.5 cm. in diameter and 7.5 cm. in length) which has been placed in his hands by the examiner, within 5 seconds of the command "look at this". The child will focus on the object for a duration of 2 seconds (P15A).

(1) Eye movements on back: In a supine position the child will follow with his eyes a moving object or light which is held at a distance of 15 - 20 cm. from his face and travels in a 180° arc from left to right.

(2) Looks and holds: In a supine position, child will stare at examiner's face for 5 seconds if it is within 15 - 25 cm. of child's eyes.

(3) Looks at hands: In a supine position the child will bring his hands in front of his face and look at them for 2 seconds, within 5 seconds of the command "look at your hands", which is preceded by the examiner touching the child's hands and bringing them in front of his face.

2. Head Control Prone

A. Placed prone on elbows with head up, child will hold his head in full face forward position for 15 seconds, within 5 seconds of being told to "look at this" and offered a toy within view.

(1) Holds head up 5 seconds: In the prone position (not supported on elbows), child will hold his head in full face forward position for 5 seconds, within 5 seconds of command "look" and offered a toy held 30 cm. from child at a height of 15 cm.

B. Placed prone on elbows, child will lift his head up to full face forward position within 5 seconds of being told to "look" and offered a toy within view.

(1) Raises head: In the prone position (not supported on elbows), child will raise his head 8 cm. off floor, within 5 seconds of a sound made 15 cm. above his head.

(2) Raises head: In the prone position supported on elbows, child will raise his head at least 15 cm. off floor to full face forward position, within 5 seconds of being told to "look" and offered a toy within view.

C. Placed prone on elbows, child will turn his head from side to side within 5 seconds of being told to "look" and offered a toy within view, to right and left sides.

(1) Head turning: In the prone position child will turn his head from centre of body to right and to left within 5 seconds of

rattle sound or toy being presented on each side.

(2) Raises head: In the prone position while holding his head up at least 15 cm. off mat, child will turn it 15 cm. to right and left within 5 seconds of being told to "look" and offered a toy within view.

3. Head Control Supine

A. In the supine position, child will hold his head 5 cm. off floor for 15 seconds, within 5 seconds of being told to "look" at a toy or at examiner.

B. In the supine position, child will lift his head 5 cm. off floor, within 5 seconds of being told to "look" and offered a toy within view.

(1) Lifts head: In the supine position, child will lift his head momentarily 2 cm. off floor within 5 seconds of being told to "look" and offered a toy held 20 - 30 cm. in front of his face.

C. In the supine position, child will turn his head from side to side while holding it 5 cm. off floor, within 5 seconds of being told to "look" and offered a toy within view.

(1) Moves head side to side: In the supine position, child will turn head following an object from centre of body to left or right, within 5 seconds of presentation on either side.

4. Rolling

A. Child will roll from back to stomach, both to right and to left, within 5 seconds of being told to "roll over". He will begin to move by turning head and turn actively moving arm and leg in sequence.

(1) Rolls from side to stomach: Child will roll from side to stomach, both to right and to left, within 5 seconds of being told to "roll to front".

(2) Rolls from side to back: Child will roll from side to back, both to right and to left, within 5 seconds of being told to "roll to back" or calling his name from behind.

B. Child will roll from stomach to back, both to right and to left, within 5 seconds of being told to "roll over", or the shake of a rattle placed just out of reach. He will begin movement by turning his head and then actively moving arm and leg in sequence (P21).

5. Sitting

A. When placed in a sitting position on a stool without back rest, with (a) back straight; (b) unassisted, i.e. without using his hands to

hold or touch stool and feet off floor; and (c) head straight and in good alignment with trunk, the child will maintain this position for 30 seconds within 5 seconds of being told to "look here" or while attending to a toy held directly in front of his face.

(1) Head erect: When in a supported sitting position on a chair with back support, child will hold his head erect without head or neck support for 30 seconds, within 5 seconds of being told to "look" and shown a toy or person's face.

(2) Sit with maximum body support: When placed in sitting position, on floor, in small armchair, or in car seat, supported on both sides and back, the child will sit for 30 seconds, looking at a toy or person's face directly in front of him.

(3) Holds head steady when carried: While being carried on examiner's hip in upright position with full trunk support, child will hold his head steady for 30 seconds, within 5 seconds of command to "look" at a toy or person.

(4) Sits with minimum support: When placed in sitting position with back against wall or in chair with back rest, child will maintain position for 30 seconds if he is told to "sit" and is looking at a toy in front of him.

(5) Sits self-supported on floor: When placed in sitting position on floor with feet in front of him and supporting himself with his hands, child will maintain position for 20 seconds after being told to "sit" while looking at a toy. Child's back may be rounded with head slightly forward.

Bi. From lying prone on floor, child will come to sitting by rotating and pushing himself up to sitting, within 5 seconds of being told to "sit up" and offered a toy within view of his sitting position (P27).

(1) Rights self: While in trunk-supported sitting position, child will right his head if he is tilted 8 cm. in any direction. This should be an immediate response.

(2) Turns head freely in sitting: While sitting in trunk-supported position, child will turn his head freely to both sides when told to "look" at an object held 30 cm. away and moved from side to side in a 180° arc.

(3) Holds head erect when pulled to sitting: From the supine position, child will raise his head and hold it steady as he is pulled to sitting position slowly.

(4) Comes to sitting with aid: From lying on his back, child will come to sitting position by pulling himself straight up without rotation while holding onto examiner's hands, within 5 seconds of being told to "sit up". Examiner may assist child by pulling his hands toward sitting position.

Bii. From standing, child will sit on a stool without back, at a height that allows his feet to remain on floor, by bending his knees and lowering himself to seat, within 5 seconds of being told to "sit down" (P53).

(1) Lowers self to sitting: From a standing position holding a stationary object for assistance, child will lower himself to sitting in chair, within 5 seconds of being told to "sit down".

C. From a sitting position on floor, child will turn to his side and lower himself to his back, within 5 seconds of command to "lie down".

6. Crawling

A. After being placed in hands and knees position with (a) hands open and fingers forward; (b) back flat; and (c) head looking in direction of movement, child will maintain this posture for 5 seconds, within 5 seconds of command to "look up", while attending to a toy or person at eye level in front of him.

(1) Prone with arms straight: After being placed in hands and knees position with (a) weight supported on open hands; (b) fingers pointed forward; and (c) elbows straight, child will maintain this posture for 5 seconds within 5 seconds of the command "look up".

(2) Heel sit with arms straight: After being placed in heel sit position with (a) weight supported on open hands; (b) fingers pointed forward; (c) hands directly under shoulders, and (d) head looking forward, child will maintain position for 5 seconds within 5 seconds of the command "look up"

Bi. From a prone position on abdomen, child will rise to hands and knees position described in Item 6A, within 5 seconds of command to "get up on hands and knees", or to get a toy held 90 cm. away.

(1) Pushes up with arms straight from prone: From the prone on elbows position, child will push self to prone position with arms straight, hands open, fingers forward, and head in midline looking straight ahead, within 5 seconds of examiner modeling posture and command of "do this".

(2) Pushes to heel sit: From prone position on abdomen, child will push to sitting back on heels with arms straight, hands open, fingers forward, and head in midline looking straight ahead, within 5 seconds of examiner modeling posture and command to "do this".

Bii. From sitting position on floor, child will turn to assume hands and knees position described in Item 6A, within 5 seconds of the command "crawl" or to look at a toy within view.

C. Child will crawl 3.5 m. with reciprocal pattern in 10 seconds, within 5 seconds of being offered a toy or told to "crawl" (P30).

(1) Creeps on abdomen: Child will move along on abdomen using arms to propel hemself 1.5 m. in 10 seconds, within 5 seconds of examiner modeling activity and command to "do this", or to get a toy.

(2) Rocks on hands and knees: After being placed in hands and knees posture, child will rock forward and backward for 10 seconds, within 5 seconds of command "rock back and forth".

7. Walking

A. After being placed in standing posture with (a) head up; (b) back straight; (c) hips extended so hip joint is straight above ankle joint, (d) knees not hyperextended, i.e., no recurvature; (e) feet externally rotated 10° to 40°; and (f) feet hip-distance apart, child will maintain position unsupported for 30 seconds within 5 seconds of being told to "stand up". Child is placed in an area devoid of any external support such as chairs, wall or tables.

A hand-held plumb line is held above and to the right or left side of the child's head so that it drops immediately behind the temporomandibular joint (midway through the earlobe), through the centres of shoulder and hip joints, behind knee and through lateral malleolus (outside of ankle joint).

(1) Bears weight on feet: In standing position with trunk supported and feet flat on floor, child will bear weight on his feet with knees in neutral position or slightly flexed, for 30 seconds on command to "stand up" or while attending to object.

(2) Stands self-supported: After being stabilized in the standing posture holding a stable object (desk or chair) with two hands, child will maintain position for 30 seconds within 5 seconds of command to "stand up" (P35).

(3) Stands self-supported: After being stabilized in the standing posture holding a stable object (desk or chair) with one hand, child will maintain position for 30 seconds within 5 seconds of command to "stand up" (p35).

(4) Stands self-supported: After being stabilized in the standing position holding one end of a 60 cm. flexible hose with one hand (examiner holding other end of hose), child will maintain posture for 30 seconds within 5 seconds of command to "stand up".

(5) Stands momentarily unsupported: After being stabilized in the standing position, child will maintain posture unsupported for 5 seconds upon command to "stand up".

(6) Stands unsupported: After being stabilized in the correct standing position, child will maintain posture for 30 seconds within 5 seconds of command to "stand up".

Bi. From sitting in chair, child will stand up without using his hands (if feet touch floor while sitting) within 5 seconds of command to "stand up" or to get a toy held in front of him at standing eye level.

(1) Puts feet flat on floor: In standing position with trunk support, child will put his feet flat on floor in weight-bearing position, within 5 seconds of command to "stand up".

(2) Pulls self to standing: From sitting position in chair, child will pull himself to standing by pulling on a stable object with two hands, within 5 seconds of command to "stand up".

(3) Pulls self to standing: From sitting position in chair, child will pull himself to standing by pulling on a stable object with one hand, within 5 seconds of the command to "stand up".

(4) Pulls self to standing: From sitting position in chair, child will pull himself to standing by pulling on a 60 cm. flexible hose with one hand (examiner holding other end of hose), within 5 seconds of command to "stand up".

Bii. From lying supine on floor, child will stand up unassisted by rotation, within 5 seconds of command to "stand up" or to get a toy held above and in front of him.

(1) Stands from sitting: From sitting position on floor, child will rise to standing by pulling up on stable object, within 5 seconds of command to "hold onto the _____ and stand up".

C. Child will walk 6 m. in 30 seconds on hard floor or carpeting, maintaining posture described in Item 7A, (a) without losing his balance; (b) using a heel-toe gait, i.e. steps on heel first and rolls to flat foot, followed by toe push-off; and (c) having reciprocal arm-swing opposite to "heel-strike" foot, within 5 seconds of command to "walk" or to get a toy.

(1) Walks when holding stable object: Child will walk designated distance (60 cm., 1.5 m., or 3.5 m.) while holding onto stable object with both hands, within 5 seconds of command "hold this and walk".

(2) Walks when holding examiner's finger: Child will walk designated distance (60 cm., 1.5 m., or 3.5 m.) while holding examiner's finger with one hand, within 5 seconds of command to "hold this and walk". Examiner's finger is held between child's shoulder and waist.

(3) Walks when holding flexible hose: Child will walk designated distance (60 cm., 1.5 m., or 3.5 m.) while holding onto a 30 cm. flexible hose with one hand (examiner holding other end of hose), within 5 seconds of command to "hold this and walk".

(4) Walks unsupported: Child will walk designated distance unsupported within 5 seconds of the command to "walk".

APPENDIX B

DEMOGRAPHIC VARIABLES FOR THE SAMPLE OF 26 SUBJECTS

Subjects N=26	Sex	*Program	Chronological age (as of March 30/77)	Height (cm)	%ile Rank	Weight (kg)	%ile Rank
1	F	H.I.	5.7	103.5	3	18.0	25
2	F	N.I.	5.7	119.5	75	21.0	75
3	M	N.I.	4.5	103.0	10	18.0	75
4	M	H.I.	4.8	102.0	10	17.0	50
5	F	D	5.11	95.5	<3	18.0	25
6	F	N.I.	5.0	114.5	75	27.0	97
7	M	N.I.	3.11	101.5	25	19.0	97
8	F	N.I.	3.11	103.5	75	15.5	50
9	M	N.I.	4.7	106.0	50	17.0	50
10	F	N.I.	5.3	97.8	<3	14.5	<3
11	M	N.I.	5.6	110.5	25	18.5	25
12	M	N.I.	3.11	95.0	3	15.5	50
13	M	H.I.	3.11	94.0	3	18.0	90
14	M	N.I.	4.9	102.0	10	16.5	25
15	F	N.I.	5.10	115.5	50	21.5	75
16	M	H.I.	4.10	102.0	3	17.0	50
17	M	N.I.	3.9	100.0	50	17.0	90
18	M	N.I.	4.11	106.5	25	18.5	50
19	M	N.I.	5.3	116.0	75	23.0	90
20	F	N.I.	4.2	109.0	75	19.0	75
21	F	N.I.	4.4	93.0	3	13.0	3
22	F	N.I.	5.0	97.0	3	15.5	3
23	F	D	5.6	97.5	3	18.0	25
24	M	H.I.	3.7	98.5	25	15.0	50
25	M	N.I.	5.0	111.5	50	23.5	97
26	F	N.I.	3.11	100.5	25	17.0	75

*Hearing-Impaired, Non-Impaired, or Down's Syndrome